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RISDON IRON WORKS, SAN FRANCISCO.

GENERAL DESCRIPTION OF THE NEW SHIPBUILDING PLANT.

The main shops and the shipbuilding plant of the Risdon Iron Works are located on the water front of the Potrero, between Nineteenth and Twenty-second streets, San Francisco, California. The property consists of thirty-five acres, lying between Georgia street and the shore line, which is here nominally Massachusetts street, and includes the former site of the Pacific Rolling Mills.

SHIPYARD PUNCH SHOP, RISDON IRON WORKS.

The main entrance is at Twentieth and Louisiana streets, four blocks east of Kentucky street, on which is the nearest electric car line. The main line of the Southern Pacific railway's bay shore extension is three blocks from the entrance on Illinois street. From this a spur runs down Twentieth street through the main gateway, which is forty feet wide, and there spreads out fan shaped into four branches. All these tracks are interconnected by curves of 150 feet radius, allowing a choice of two or three routes from almost any point to any other, thus preventing the annoyance and delay of blocking traffic. For instance, there are four possible routes from the machine shop to the shear legs—the ultimate destination of all large marine work. The total length of trackage about the works is four miles.

The general arrangement of the buildings is as follows: North of Twentieth street is located the shipbuilding department proper. It consists of the mold loft and ship tool building, plate racks and shipbuilding ways. South of Twentieth street the first tier of buildings is as follows, going toward the bay: New office, blacksmith shop, angle-bar shed, warehouse, joiner and ship-pattern shop and fireproofing and riggers shops. The next tier south consists of machine shop, storeroom, power house, copper shop and boiler house. The following tier contains the erecting shop, extension to the machine shop, pattern shop, boiler shop, foundry, flask shop and flask yard. There is a complete line of wharves on the bay frontage, including a fitting-out slip, surrounded on three sides with wharfage and railroad tracks. It will be noticed that the grounds are amply provided with railway facilities —in fact, a track has been laid wherever it could be of use. As all the curves are 150 feet radius, the usual

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flatcars and railway yard locomotives have access to all parts of the works. The complete track system also makes it possible to utilize all the space not occupied by buildings for storage. Material and all heavy articles are carried about the works by three yard or locomotive cranes, having a capacity of ten tons. These are also used for switching cars.

The buildings are constructed of structural steel, covered with galvanized corrugated iron, thus being fireproof throughout. The foundations are concrete piers. Under the machine shop, boiler shop, foundry and blacksmith shop, piers are laid upon bedrock, as the site of these buildings has been excavated from the surrounding hills. The ship tool building columns and each separate machine rest upon concrete piers nine feet deep, which, in turn, are built upon piles from seventy to ninety feet long, driven to bedrock. The joiner shop is similarly supported, though the distance to bedrock is not so great.

The lighting facilities are ample. Each shop is completely equipped with arc and incandescent lamps, so that work can be carried on continuously night and day when necessary.

POWER.

Four kinds of power are distributed completely throughout the works—compressed air, hydraulic, steam and electric.

Compressed air is used for hoists, drills, riveters, caulkers and other pneumatic tools, the provision for the ship building and repairing plant, wharves and fitting out slip being especially complete.

Hydraulic power is used for large riveters, punches, jacks, drop forging presses, hoists, keel plate bender, etc., and also for testing.

Steam is used outside the power-house itself for steam hammers and heating purposes.

The main source of power, however, is electric. Nearly all machines, except the special hydraulic and pneumatic and the steam hammers, which require over five horse power, are independently driven by electric motors. The smaller machines are belt driven from line shafts, each having its own motor.

POWER HOUSE.

This is a thoroughly modern, one-story steel structure, 100 by 150 feet, situated in the center of the plant. It is the producing and distributing point for the different power systems mentioned above, and also serves for the salt and fresh water distribution for drinking and fire purposes, as well as petroleum distribution for the boilers, blacksmith shop and boiler shop fires.

The boilers (now being installed) are of the Heine water-tube type, and will eventually supply all the power used in the works. They are oil burning, as are also those upon the locomotive cranes.

The electrical equipment includes: Two 250 K. W. static transformers, 11,000 to 440 volts; two 150 K. W. static transformers, 11,000 to 196 volts; one 50 K. W.

VIEW OF THE RISDON IRON WORKS FROM THE WATER.

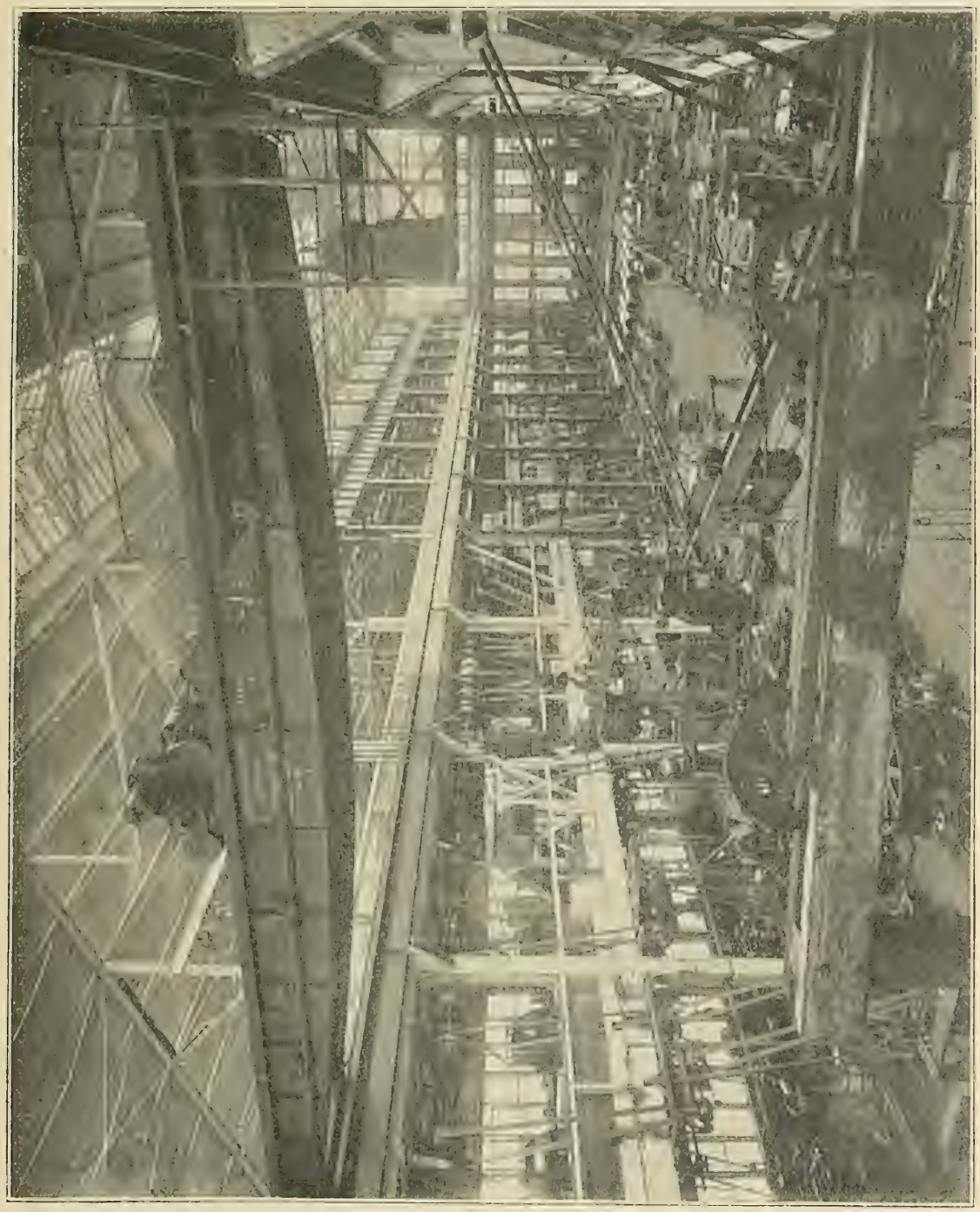
static transformer, 2,200 to 110 volts; two 25 K. W. static transformers, 2,200 to 110 volts; two 10 K. W. static transformers, 440 to 110 volts; one 250 K. W. rotary converter, 196 to 220 volts. All are supplied with the necessary switches, ammeters, volt meters, watt meters and other requirements. At present power is taken from the mains of the Independent Light and Power Company, at 11,000 volts, two-phase, 60 cycles. Provision, however, has been made to install generators which will furnish all the power required.

The direct current system is used to operate all the overhead traveling cranes and two or three small motors. The alternating current system supplies power to the remaining motors and the arc and incandescent lamps.

The hydraulic power system is supplied by a 150 horse power, triple throw, double acting pump, driven by an induction motor. This pump produces a pressure of 1,500 pounds per square inch, and feeds a battery of four accumulators, which automatically control the output. The power is then distributed through a system of manifolds to the various departments.

The compressed air is furnished by a 300 horse power, two stage, intercooled compressor, directly connected to a compound Corliss engine. Provision is made for adding more when required. The compressor delivers through a receiver to the mains at a pressure of 100 pounds per square inch.

sure on the mains. As the salt water is also used for condensing and sprinkling the grounds the pump is constantly in operation, thus being ready at all times for emergencies. By a system of valves the fire pumps can be changed over to the fresh water system if necessary, or in case of fire will operate both until the ar



INTERIOR VIEW OF MACHINE SHOP LOOKING SOUTH.

The fresh and salt water systems distribute through the manifolds throughout the plant, the former direct from the Spring Valley mains, the latter from a 16 by 9 by 12 inch Smith-Vaile fire pump, which will deliver 750 gallons per minute. This is governed by a Metz pump governor, so that it keeps a constant pres-

rival of the city's engines, when the latter will take fresh water, leaving the salt water for the shop force.

There is also in the power-house a 100 horse power induction motor driving a line shaft which operates a blower for the blacksmith shop fires, an auxiliary air compressor and an auxiliary hydraulic pump.

OIL SYSTEM.

The oil system is very complete, crude petroleum being the principal fuel throughout the works. The storage tank holds 7,000 barrels and is surrounded by a brick wall 80 by 55 feet, 9 feet high, forming a reservoir with cemented floor, which will contain the entire contents of the tank. One corner is walled off, forming a pumping room. Here is located a Goulds rotary pump operated by a five horse power motor and having a capacity of 250 gallons per minute. This is connected to the pipe lines so as to be used either to empty tank cars into the storage tank or pump oil into the supply tank at the power house. It will empty a car in twenty-five minutes or fill the storage tank (which will last about ten hours) in fifteen minutes. Four cars can be connected to it at one time. The supply tank is buried beneath one end of the power house. Above this are two duplex steam pumps arranged in duplicate. These pump the oil through a heater to the boilers. They also pump oil to the blacksmith and boiler shops, where it is used in the angle furnace, rivet heating furnaces and other fires.

MACHINE SHOP.

This building is a carefully designed steel structure, 400 by 110 feet, is unusually lofty for such buildings, and is elaborately lighted and ventilated. The tools have been carefully chosen to properly handle the heaviest marine and mining machinery as well as the finest and most accurate machine work. They were supplied by the Niles-Bement-Pond Company, and there is no machine shop in the country that contains larger tools or a more complete equipment. All large new tools have their own direct connected motor. Among these are a 24 by 16 foot vertical boring mill, four 8 foot vertical boring mills, a horizontal boring and milling machine of 14 feet horizontal travel by 8 feet vertical travel, a 60-inch by 40-foot heavy forge lathe, a large vertical planer, and many others.

Above the ground floor are two galleries on each side of the building. The lower galleries are each 125 by 25 feet, extending from the north end. The upper galleries are of the same width, extending the full length of the building. The lower ones are filled with small tools, vise benches, etc., as is the east upper gallery, the west being at present occupied by the electrical storeroom and workshop, office and the temporary draughting room of the works. In the remaining 275 feet not occupied by the lower galleries (that is, the south or erecting end) run two 10 and 15-ton electric overhead traveling cranes of 25-foot span, 22-foot lift. In the middle fifty feet, which is clear to the roof, runs a 20-ton crane the full length of the building. It has a lift of thirty feet. Besides these a 60-ton crane of the same type is to be installed in the south end, where the erecting shop is located. This will be above the 20-ton crane, and will have a 50-foot span, 45-foot lift and a 275-foot run. The 15, 20 and 60-ton cranes all have 5-ton auxiliary hoists.

The ground floor is paved throughout with red wood blocks, set on end in asphalt and coated over with tar and gravel.

The machine shop tool room is built into one side of the main building about midway in length. This is 30 by 60 feet, two stories high, encased on three sides, with the fourth separated from the main shop by wire netting only. It contains a complete equipment of the finest machines for making tools, and a large assortment on hand of all the tools necessary for a modern shop.

BOILER SHOP.

The boiler shop and foundry adjoin end to end, allowing space through the partition for the railroad track, which runs through the boiler shop close to this partition, and serves as an outlet for both. The shop is a thoroughly substantial, high, well-lighted building 250 by 184 feet. It also is paved with wooden blocks. Adjoining is the foreman's office, 14 feet by 14 feet 6 inches, raised eight feet above the floor, and so situated as to command a view of the entire shop. A toolroom 61 feet by 14 feet 6 inches is situated under and to one side of the office. It is separated from the shop by wire netting, the other three sides being cased in. There is also a room 45 by 30 feet, fitted with racks for bolts and rivets. The main shop has three overhead electric traveling cranes, one 60-ton, with 56-foot span and 41-foot lift; one 20-ton, 50-foot span and 41-foot lift and one 10-ton with 33 1-2-foot span and 30-foot lift. All have 5-ton auxiliary hoists.

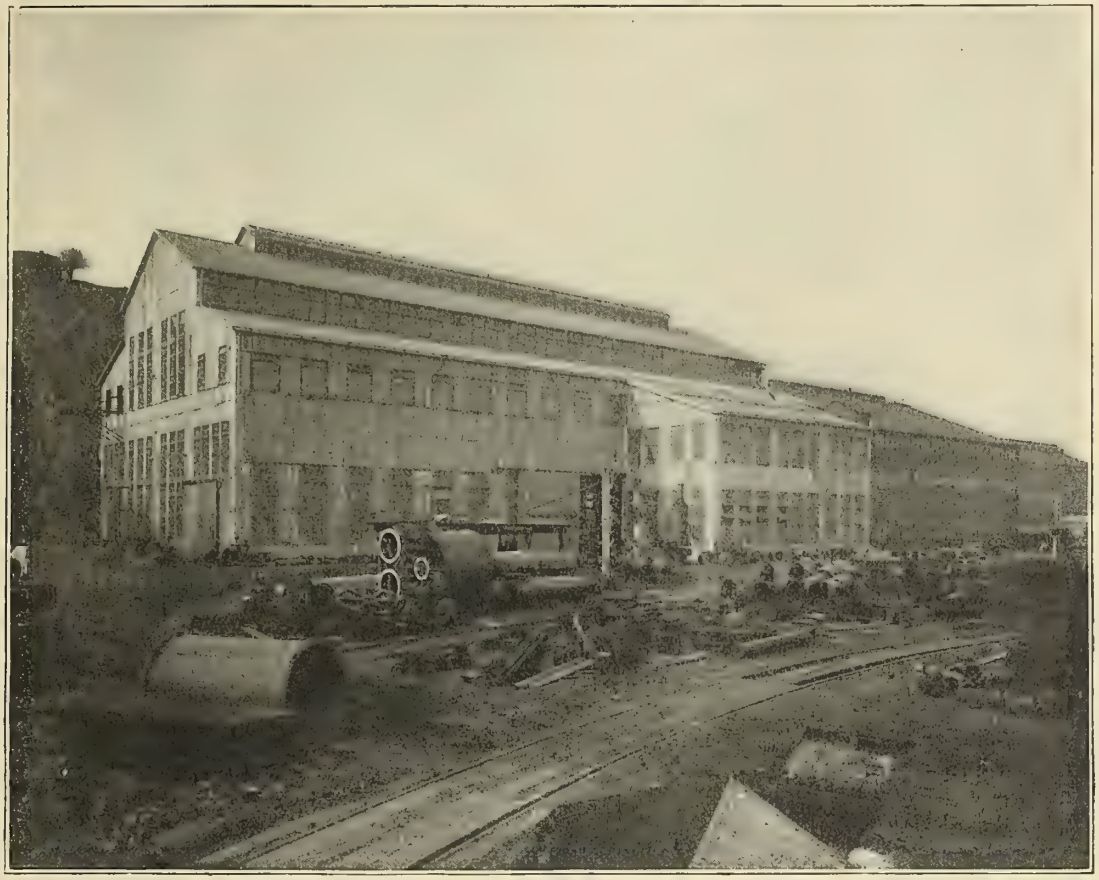
The tool equipment consists of bending rolls, hydraulic flanging presses, hydraulic riveters, air riveters, punches and shears, pneumatic hammers, and in short, everything to make up a modern boiler shop is provided. Among the principal machines are a large punch with a 60-inch jaw, capable of punching a 6-inch hole in a 5-8-inch plate. Here are also located 12-foot 6-inch rolls, capable of rolling a 1 1-4 inch plate. There is a gang drill for drilling large boilers, on which three men can operate at one time, and a large flange punch of the latest improved pattern for work on boiler heads.

Besides there are drills of all sizes and kinds, the latest improved types of bevel angle and plate shears, post jib cranes with hydraulic hoists, hydraulic flanging clamps and bending machines, bending slabs, five forges, rivet-heating furnaces, etc. Outside the building and alongside the railroad tracks are the plate racks, also tube racks 60 feet long by 80 feet high. Air is furnished the forges by a No. 8 Sturtevant steel pressure blower belted to the line shaft.

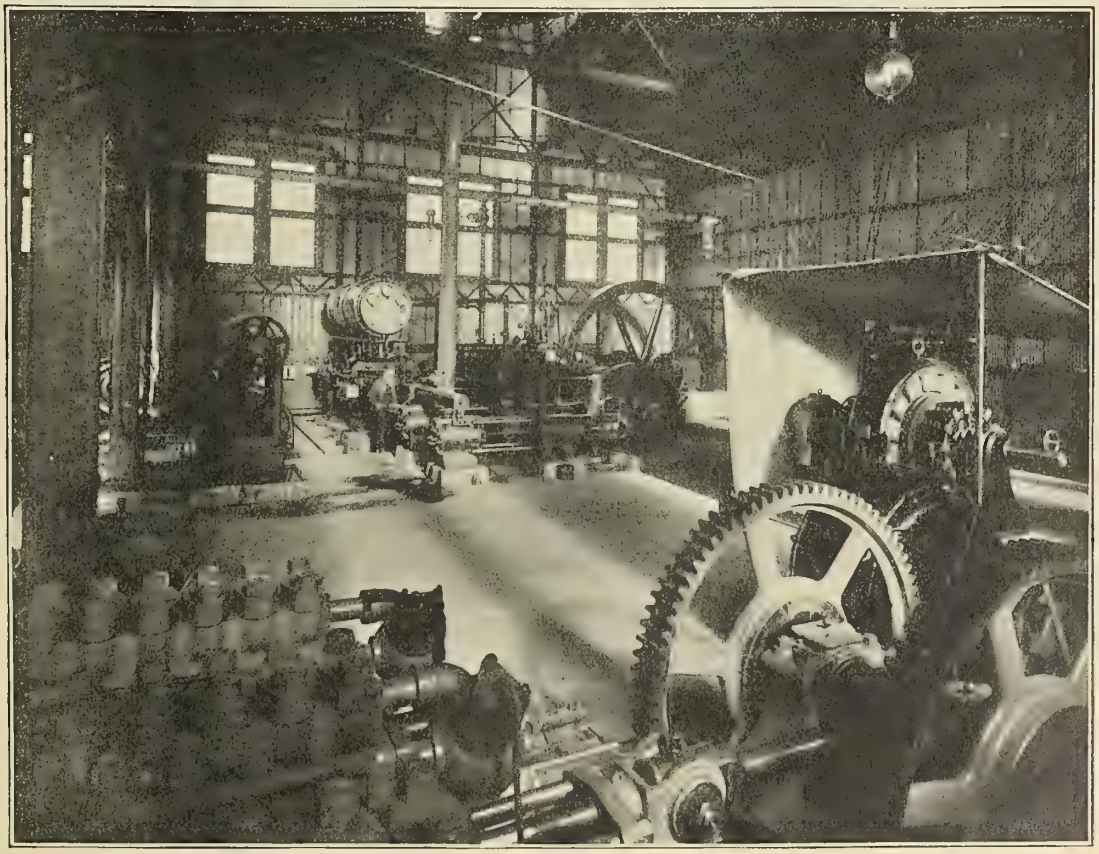
FOUNDRY.

This is a steel building covering an area of 250 by 200 feet. It is provided with two 30-ton electric cranes and one 10-ton electric crane, all equipped with 5-ton auxiliary hoists, besides various post jib cranes distributed throughout the shop. The principal crane has a lift of 40 feet. The building is well lighted and ventilated throughout.

The foundry equipment includes four cupolas for melting iron, with an aggregate capacity of 75 tons and a reverberatory furnace. The core department contains four core ovens, 12 by 18 feet, 14 feet high; one core oven 18 by 25 feet, 14 feet high; one small core oven with turret and shelves, and a cement core floor 40 by 100 feet. There is a large cupola deck having ample space for storing material for immediate use, while adjoining the cupolas is room for storing prac-



MACHINE SHOP.



INTERIOR OF POWER HOUSE.

tically unlimited quantities of pig iron and coke, which are easy of access. Under the cupola platforms are large bins with cement floor for storing loam. There is a large Chili mill for loam work. The blower plant consists of one Root blower, No. 6, geared to a 30-horse power motor, and one Root blower, No. 5, geared to a 20-horse power motor.

BLACKSMITH SHOP.

This shop is intended and designed to handle all work of that character for both machine and ship work. The building is of steel, 350 by 65 feet, and is especially designed as regards ventilation. The sides and ends are made up entirely of sliding doors, which can be moved in either direction, securing a cool shop in the hottest weather, and allowing large pieces to be swung in easily or carried out at any point. The following are among the tools included: Hydraulic press for making and welding bands and for drop forging, electric beveling machine for angle iron, one 3-ton steam hammer, one 2-ton steam hammer, one 1-ton steam hammer, one 1,500-pound steam hammer, two 1,100 pound steam hammers, one belt hammer, two 20-ton steam jib cranes, two 10 and 6-ton wood jib cranes, one 10-ton steel jib crane, one forging furnace, from which the waste gases are utilized in a steam boiler for supplying steam to the cranes.

The shop also contains bending slabs 45 by 45 feet, and has a full equipment for forging cranks and heavy shafting, shipsmithing, machine forgings, etc. There is room for forty-five fires arranged along the center and on either side.

PIPE SHOP.

This shop immediately joins the boiler shop on the opposite end from the foundry and extends north to the power house and copper shop. These form the ends, the sides being open. The roof covers a space of 133 by 186 feet, which is not excessive when we take into consideration the fact that the Risdon Iron Works make more sheet pipe than any other single firm in the world. This shop is also used extensively for doing light pipe work, making smokestacks, dredger buckets, etc.

SHIP TOOL BUILDING.

The ship tool building, containing also the mold loft, has been very carefully designed, and is perhaps the most thoroughly and elaborately equipped for saving labor and turning out work rapidly of any in America.

It is of steel, 433 by 85 feet wide, with an additional 15 feet of overhanging shed running the full length. This side is open, the columns being 40 feet apart and facing the shoreward ends of the shipbuilding ways.

The mold loft floor, having a perfectly clear expanse of 433 by 85 feet, is probably the largest in America. Being supported every ten feet by latticed girders, five feet deep, it is practically rigid.

The most noticeable feature of the ship tool shop is the elaborate system of trolleys and crawls for distributing material and handling it at the machines. There are 24 crawls, ranging from 6-foot to 17-foot span, and supplied with cross trolleys for handling plates and angles, nine 3-foot gauge trolleys running on the through tracks for distributing material, and two narrow gauge trolleys for handling angle bars at the double angle shears and angle planer. This shop is completely equipped with new tools furnished by Hillis and Jones and others.

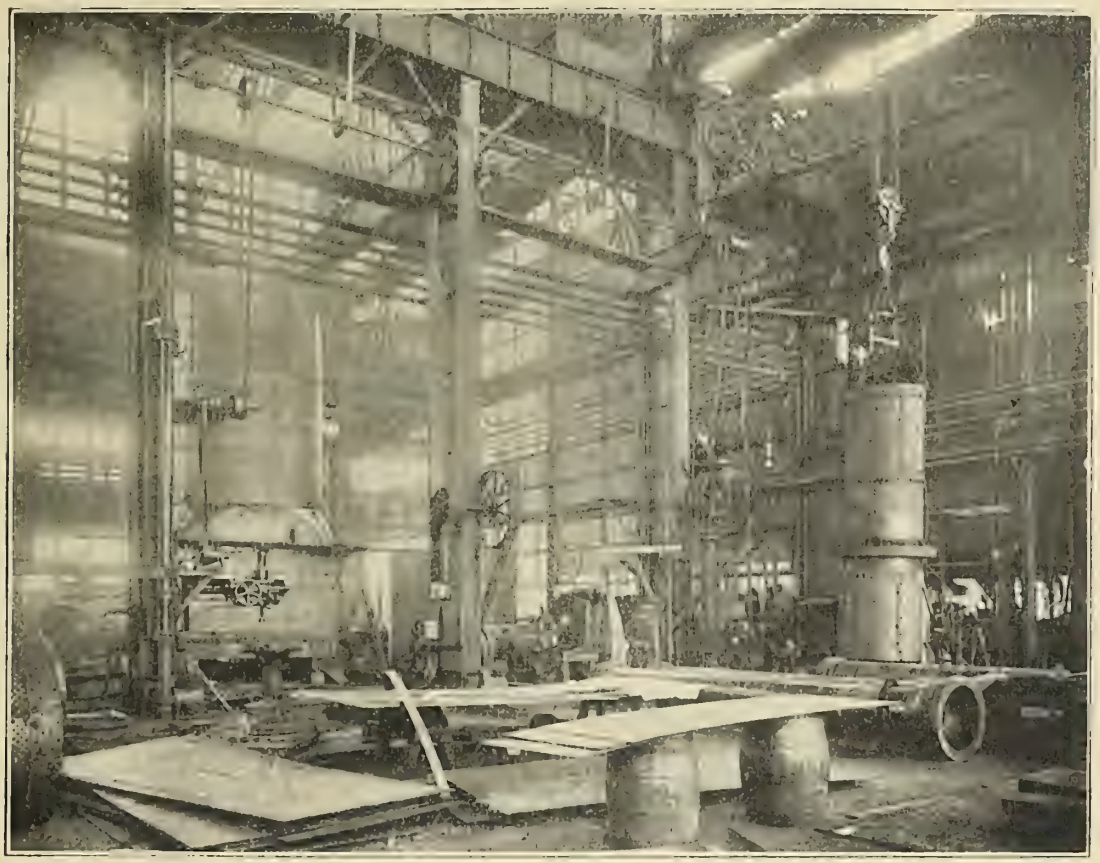
Among the larger ones we have a 30 foot 2 inch plate bending roll, operated by a 35 horse power A. C. motor, and a 15 horse power A. C. motor for raising and lowering the top roll. An hydraulic keel plate bender 24 feet 8 inches long 8 feet wide, taking 4-inch material; one 48-inch heavy combined punch and shear, motor driven; one 42-inch heavy double punch, motor driven; one 36-inch heavy combined punch and shear, motor driven, and six smaller single belt driven punches or shears. One set of mast bending rolls 12 feet 2 inches wide, motor driven; one set of straightening rolls 86 inches below housing, motor driven; an angle iron planer for any length and any degree of straightness; two plate planers 30 feet long, motor driven, and fitted with hydraulic clamping jacks; one large combined horizontal punch and beam bender; one medium sized horizontal punch, radial countersinkers, drill presses, etc., over which are two lines of track carrying twelve crawls of 11-foot span each. Completely around these runs a through track carrying four 3-foot trolleys for distribution. Just outside this oval are 6-foot gauge tracks for the four small single ended punches or shears and the two 30-foot plate planers; 13-foot gauge tracks for the mast rolls and straightening rolls, and clear across one end are two 17-foot gauge tracks completely covering the large 30-foot bending rolls, which will take a plate two and a half inches thick, and the hydraulic keel bender which will bend a plate four inches thick. Material is brought in on a 3-foot track running the entire length of the overhanging shed and extending beyond enough to take from the gantry crane running over the plate racks. The 3-foot track is twenty-three feet from the ground, allowing the locomotive trains to swing underneath the railroad track, paralleling the trolley just outside the shed. All the other trolley tracks are fourteen feet from the ground. All the crosstracks run out to meet this through track, so that material can be taken to any machine in the shop, or the finished work removed without disturbing any other machine, even when all are in use. Besides the machines mentioned above, there are two radial counter-sinking and drilling machines working over a long roller table, and various smaller drill presses.

MISCELLANEOUS BUILDINGS.

Besides the principal buildings mentioned above there is a completely equipped joiner and ship pattern shop, two stories high, 200 by 100 feet, at present supplying all the pattern work; a copper shop, 110 by 45 feet; a brass foundry 80 by 110 feet; a two-story pattern storage warehouse 80 by 170 feet; miscellaneous warehouses aggregating 132 by 200 feet; an emergency hospital 23 by 75 feet; a stable 35 by 123 feet, and a Babbitt melting and fitting shop 16 by 25 feet.

WATER FRONT.

The wharfage facilities include nine wharves, with frontage as follows: No. 1, 387 feet long; No. 2, 300



BOILER SHOP.

MIDDLE BAY OF FOUNDRY.

feet long; No. 3, 48 feet long; No. 4, 300 feet long; No. 5, 138 feet long; No. 6, 235 feet long; No. 7, 42 feet 9 inches long; No. 8, 300 feet long; No. 9, 150 feet long. The total frontage is 1,900 feet. All are connected by railroad tracks, and have hydraulic, compressed air and electric connection with the power house, besides salt and fresh water plugs. The 100-ton shear legs are located on wharf No. 1. Besides the main lift of 100 tons, there is a masting hoist of twenty tons capacity. The shear legs have an overhang of thirty-six feet, a spread of forty-five feet, and a clear lift of ninety feet.

SHIP YARDS AND WAYS.

There is room at present for building five vessels 600 feet long and one 700 feet long, or a greater number of smaller vessels occupying the same length. Provision is made for handling all material in the course of construction by overhead traveling cranes.

PLATE RACKS.

These are located along the ship ways and extending up to the blacksmith shop and the ship tool building. They will be covered by a gantry crane, with a span of sixty feet, running their entire length and delivering material to either the blacksmith shop or the trolleys of the ship tool building. Railroad tracks pass through them underneath the gantry, which will be high enough to allow the locomotive cranes to pass underneath.

LAUNCHES.

The Risdon Iron Works is well supplied with launches, having three operated by gasoline, for service between the Potrero works and the downtown office and branch. They are fifty-five feet, fifty feet and thirty-six feet long, respectively, and are very swift, the largest being equal in speed to anything on the bay of the same dimensions.

EXPANSION.

The total ground owned is thirty-five acres, while the aggregate area under cover at present is approximately eight acres, with another acre provided for in the near future. This leaves twenty-six acres for ship yard, storage and future expansion. The total floor area, with what is provided for, amounts to ten and one-half acres.

CITY OFFICE.

The new city office and branch machine shop is a handsome building located at the corner of Steuart and Folsom streets, near the Folsom street wharf. It contains a storeroom for made-up stock, an exhibition of sample machines, and a small shop for hurried repairs and other work of similar nature.

THE GROWTH OF THE RISDON.

The Risdon Iron and Locomotive Works, though entering upon a remarkable era of expansion, so extensive and divergent that the old landmarks of its development are quite lost sight of, is yet one of the oldest and best established manufacturing institutions on the Pacific Coast. In the early days, when mining was the prime source of wealth on this coast, its machinery was the most important manufactured. The Risdon works, being a pioneer in this field, has grown up with it, expanding as it developed, and contributing its full quota of original inventions, improved forms and labor saving devices, which have made California's methods a model of mining on a large scale as a practical science the world over. Though this will always remain an extensive and lucrative field, other lines are developing into even greater magnitude—shipbuilding, for instance. Into this the Risdon is prepared to bring the same energy, improved methods and conscientious workmanship which have built up its remarkable trade in the former branch.

The work which this company is now prepared to do lies in five broad fields, each complete in all its branches. These are shipbuilding, marine engineering, mining machinery, structural iron work and miscellaneous engine and machine work.

SHIPBUILDING.

In the first the equipment is entirely new and up-to-date, and includes facilities for building six steel vessels at once, 600 or 700 feet long and up to 80-feet beam, or a larger number of smaller vessels. There are also provided nine wharves for the repair and fitting out of steamers.

MARINE ENGINEERING.

The second department is that of marine engines, high pressure, condensing, compound, triple or quadruple expansion; marine boilers of the latest improved Scotch, locomotive or water-tube type, for burning either coal or crude petroleum; condensers, feed pumps, distilling apparatus, evaporators, refrigerating and ice machines, steering engines, windlasses, winches, coal and ash handling machinery, and in fact, all that goes to operate an ocean-going steamer of the largest and most elaborate type.

MINING MACHINERY.

The third or mining machinery class is so broad that only a bare mention can be made of the various types. For mining proper there are hoisting and pumping engines, steam, hydraulic and portable, and rock drilling, tramway and ventilating machinery. For ore reduction there are smelting furnaces for silver, lead and copper, reverberatory and mechanical roasting furnaces, revolving and kiln ore dryers, stamp mills, roller mills, concentrators and chlorination works. Among the specialties in this line manufactured by the Risdon are Bryan roller mills, Johnson concentrators, steel whims, Hoskins's giants, Wright calcining furnaces, Pelatan clerici process machinery and Evans' hydraulic elevators. Among the different methods of mining, one in particular has become of paramount importance in the last few years. It is working the gold bearing river beds by means of bucket and even caisson dredgers.

The Risdon has built a great number of these, and holds the exclusive rights for building the R. H. Postlethwaite dredge, undoubtedly the most successful one on the market. As evidence of this might be stated the fact that four years ago there was no successful dredger working in California, although many were left as failures on the banks of rivers throughout the state.

Since the first Risdon dredger was built on the Feather river there have been over thirty of them made, and the Risdon is now building nine of these

machines. The dredgers have not only been used in California, but are in operation all over the western states and among the gold districts of Africa, Alaska and Mexico.

STRUCTURAL IRON WORK.

In the fourth class—that of structural iron and steel work—the Risdon has contributed to the most important recent building operations of San Francisco, notably the Union Depot, or ferry building, and the Claus Spreckels building. Mention should also be made of the Spreckels Sugar Company's plant, at Spreckels, Monterey County, California. The main building is 582 by 103 feet, six stories high and contains over 3,600 tons of structural steel.

been built extensively for many years, later examples being three 3,000 horse power water wheels directly connected to polyphase alternators for the Bay Counties Power Company. Another important branch is that of hydraulic steel pipe building, of which they are the most extensive builders in the world.

The miscellaneous group is too extensive and diversified to allow of specifying more than a few types. For instance, Corliss engines, Risdon air compressors, Heine safety water-tube boilers, Smith-Vaile pumps, all sorts of manufacturing and special machinery, boiler fixtures, all kinds and sizes of valves, pneumatic and hydraulic tools.

BLACKSMITH SHOP.

ENGINE AND MACHINE WORK.

The last class, comprising miscellaneous engine and machine work, contains many diverse branches, some, notably sugar machinery and hydraulic machinery, being almost of sufficient importance and magnitude to rank with the main groups. The former includes most of the machinery used on the sugar plantations of the Hawaiian Islands, consisting of crushers, vacuum pans, filter presses, settling tanks, etc., besides engines, trash burning boilers, pumps, water wheels, motors, etc.

In hydraulic machinery the Risdon is a pioneer, having built the real prototype of the modern tangential water wheel with re-action buckets, frequently called the "Pelton type" water wheel, which has

INDUCED DRAFT ON STEAMSHIP NECKAR.

The steamship *Neckar*, of the North German Lloyd Company, which recently made her maiden voyage to this country, is built with the idea of reducing the expenses of operation to the minimum consistent with good engineering. She is of the intermediate type of freight and passenger steamer, and was built by J. C. Tecklenborg, of Geestemunde, Germany. She is 500 feet long between perpendiculars, 58 feet extreme beam, 37 feet deep and of 11,200 registered tons. At a load draft of 28 feet the displacement is about 16,250 tons.

Means are provided for quickly handling the cargo on this ship. There are eight cargo hatches, four forward and four aft, and four steel masts stepped between hatches Nos. 1 and 2, 3 and 4, 5 and 6, and 7 and 8. The

fore and jigger masts are equipped with two derrick platforms, one on the forward and one on the after side of the mast. The main and mizzen masts are fitted with one derrick platform each, while two other platforms are located at the break of the bridge deck, one forward and one aft, and each platform has sockets for four cargo derricks. Thus hatches Nos. 1, 4, 5 and 8 have four derricks each, and the other hatches eight derricks each. At each mast are four steam winches, making a total of sixteen winches and thirty-two derricks.

Plain but roomy cabins for the first-class passengers are located amidships in a two-deck bridge house.

The propelling machinery consists of two sets of four cylinder quadruple expansion engines, with cylinders 23.80, 33.88, 48.03 and 71.25 inches in diameter by 51.13 inches stroke. The high-pressure cylinder is forward, the low-pressure second, the second intermediate third, and the first intermediate at the after end. The sequence of cranks is, looking aft, high, second intermediate, low and first intermediate, the crank angles being according to the Schlick system of balancing. The crank webs of the end cylinders have counterbalance discs. These two cylinders have piston valves, that on the high being forward and that on the intermediate being on the aft end of the engine. Slide valves are fitted to the other cylinders, placed facing each other, and all valves are actuated by Stephenson link motion. This arrangement gives a compact and well balanced engine. The cylinders are separate castings mounted on cast iron A frame housings, and these housings are braced to each other at the top by cast iron box girders. The cylinders are secured to each other by rods screwed into lugs on the cylinders. The condenser is cast in the frame of the first and second intermediate cylinders.

Steam is supplied by three single and two double end boilers, and it is in this department that the largest coal economy has been attained. Two of the single end and the two double end boilers are fitted with Ellis and Eaves' system of induced draft. The other single end boiler, which is located in a recess of the cross bunker, is not fitted with this system, as it is often used as a donkey boiler when in port.

The dimensions of the boilers and heaters are:—

	Single End.	Double End.
Diameter	14 ft. 3¼ in.	14 ft. 3¼ in.
Length	11 " 2⅜ "	20 " 9 "
Number of furnaces	3	6
Inside diameter of furnace	39⅜ in.	39⅜ in.
Number of tubes	376	752
Diameter of tubes (plain).	2¾ in.	2¾ in.
Heating surface	2370 sq. ft.	4780 sq. ft.
Grate surface	59 "	118 "
Total H. S.	16,670 sq. ft.	
" G. S.	413 "	
Number of tubes in heater	342	
Size of tubes	2¾ in. O. D. No. 14 B.W.G.	
Length of tubes	5 ft. 10½ in.	
Coal burned, approx	1050 tons.	

The gases on leaving the smoke boxes of the boilers, which are fitted with the induced draft, pass upward through the air-heating boxes, and from these direct to the fans by as short a route as possible, the fans discharging directly into the funnel, so that there is as little loss as possible due to tortuous passages; and indeed it has been found that the vacuum in the smoke-box is the same as at the fan inlet.

The form of heater as used on the *Neckar* is composed of a number of vertical tubes, through which the products of combustion pass. As it is desirable to have nearly the same amount of heating surface in this heater as in the boiler tubes, and as the vertical space is limited, these heater tubes were made of larger diameter than is customary in installing this system. Owing to the low specific heat of air it is found that by bringing it into close contact with the surface from which the heat is derived it is very easy to raise its temperature even with comparatively short tubes. The above object is gained by a very simple device, which in practice is found to be thoroughly satisfactory. At a point about one-quarter the length of the heating tubes a diaphram plate is placed. The holes in this plate through which the tubes pass, do not fit the tube, but are 1-2 inch larger than the outside diameter of the tube. The air can circulate freely through the upper portion of the tubes above the diaphragm plate, but to reach the valves in the furnace it is drawn in thin annular streams round the heated tubes, from which it takes up the heat at once.

As the heated air is drawn from the ends of the heating boxes, there would be a tendency for the air entering the annular spaces at the corner of the box farthest from its exit to take the shortest course in a diagonal direction across the tubes. This is prevented by placing vertical division plates between the tubes, so that no matter where the air enters it is forced to travel over every portion of the heated surface before escaping.

On leaving the heating boxes the air is led down passages on both sides of the smoke-boxes and enters the fire through the regulating valves on the furnace front. Five valves are here provided, two of which communicate with the ashpit direct, and three with the furnaces above the bars, the air passing through perforated baffle plates in the ordinary way. The two upper side valves are only required when burning bituminous coal very rich in hydro-carbon, in which case an excess of hot air is necessary to insure perfect combustion of the gases in the combustion chambers. A cast iron ashpit door is fitted to the lower portion of the front; this door is perforated with a number of 1 1-4 inches holes, so as to allow the entrance of a certain portion of cold air under the bars. Experience has shown that any tendency which may exist for the bars to become red-hot and burn down is entirely obviated by raising them about 2 inches higher at the bridge than at the furnace front, which is just the opposite of the usual practice.

The fans are placed athwart-ships in such a position as to discharge directly into the funnel, and fitted with expanding outlets which obviates all possibility of back pressure on the fans, and greatly reduces the power required to drive them. The fan engines are in the engine room, in a recess above the cross bunker, the connection to the fans being made by means of shafting provided with flexible couplings to compensate for any twisting which may take place due to the expansion of boilers and casings. The engines made by Messrs. Thwaites Brothers, Ltd., of Bradford, are of the compound single acting type, the consumption of steam is small; they are practically noiseless and require very little attention.

The *Neckar* left Bremerhaven for her maiden voyage across the Atlantic on May 4, 1901, at 12 o'clock, and arrived in New York on the evening of May 15th without meeting rough weather. On this trip a test of the draft system was made by experienced engineers, and the efficiency of the system may be seen by noting the rise in temperature of the air entering the furnaces through the heaters. Taking the average for the voyage, it is seen that the air was raised from 139 degrees Fahrenheit to 314 and 327 degrees, and that the temperature of the escaping gases was reduced from 526 to 400 degrees. The coal burned on the voyage was 1,050 tons, and the average indicated horse-power was 6,000, making the pounds of coal per I. H. P. per hour 1.62. The mean draft for the trip was 21 feet 7 inches, and the average speed was 14.1 knots.

Log of induced draft system on steamship *Neckar*, voyage No. 1, Bremerhaven to New York.

Boiler pressure	208 lbs.
Revolutions of fan engines, port	191
" " " starboard	194
Vacuum by water gauge	
At fan inlet	1⅝ in.
" suction forward port	1¼ "
" " " starboard	1¼ "
" " aft port	1¼ "
" " " starboard	1¼ "
Grates over	7-16 "
" under	5-16 "
Velocity of air in feet per minute	
Ashpit old fires	667 ft.
" new fires	730 "
At entrance of air heaters	230 "
Temperature in degrees Fahrenheit	
Air entering fans, old fires	314 deg.
" " " new "	327 "
At fan suction forward	526 "
" " " aft	526 "
Escaping gases in funnel	400 "
Air at entrance of heater	139 "

Design of engines of varying powers from one set of drawings.—In connection with the articles on this subject by Professor H. C. Sadler, we are in receipt of a communication from M. J. A. Normand, of Havre, France, in which he calls attention to an article by him upon the same subject, and published in *Engineering*, Vol. LX, p. 54.

Shipbuilding Returns. — During the six months ended December 31, 1901, there were built in the United States and officially numbered by the Bureau of Navigation 717 rigged vessels of 154,073 gross tons compared with 568 rigged vessels of 179,229 gross tons for the corresponding six months of 1900. Canal boats and unrigged barges are not included. The principal decline, 19,752 tons, is on the Atlantic seaboard, and is attributable to work on several large ocean steamers, which will be completed during the coming six months. Included in the six months figures are 38 vessels, each over 1,000 tons, and aggregating 103,832 tons. Of these 14 steel steamers, aggregating 52,310 tons, were built on the Great Lakes. Four are for the seaboard, two banana steamers, *Watson* and *Buckman*, each of 1,820 tons, the *Hugoma*, 2,182 tons, and the *Minnetonka*, 5,270 tons. The *Minnetonka* will be cut in two to pass the canals. On the seaboard 15 wooden schooners of 24,864 tons were built, five steel steamers for the coasting trade, and one steel ferry boat, aggregating 20,964 tons. Square rigged vessels are the steel ship *William P. Frye*, 3,374 tons, and two barkentines on the Pacific, aggregating 2,310 tons.

THE THEORETICAL AND PRACTICAL METHODS OF BALANCING MARINE ENGINES, I.

BY NAVAL CONSTRUCTOR D. W. TAYLOR, U. S. N.

A Comprehensive Abstract of the Prize Paper Presented Before the Society of Naval Architects and Marine Engineers, November, 1901.

The paper opens with introductory paragraphs on sources of vibrations other than the engines, on certain elementary features of the vibrations of ships, on the present status of engine balancing, and on the effect of slack bearings or improper valve setting. The author then takes up his main subject as follows:—

GENESIS OF UNBALANCED FORCES.

6. Let us consider first an engine with a single cylinder. If steam is in the cylinder, but the piston is not moving, the pressure upon the piston and the pressure upon the cylinder head are equal and opposite. These pressures neutralize one another through the engine framing, and there is no external or unbalanced force communicated to the engine supports. If, however, the piston, with its attached weights, is moving and being accelerated, that portion of the steam pressure necessary to accelerate it is absorbed in giving energy to the moving parts, and hence is not transmitted to the engine framing. It follows that the pressure on the cylinder head which tends to move the framing in one direction is only partially balanced by that portion of the steam pressure upon the piston which is transmitted to the engine framing via the piston rod, connecting rod, and crank shaft. It is obvious, then, that the unbalanced forces developed when a single-cylinder engine is revolving are equal and opposite to the forces necessary to accelerate or retard the moving parts as the engine turns over.

RESULTS OF INVESTIGATION OF SINGLE-CYLINDER ENGINE.

7. In Appendix A* will be found a detailed investigation of the geometry and mechanics of the motion in the case of a single-cylinder engine. Referring to these we find that the weights of the moving parts of a single-cylinder direct-acting engine are equivalent to a reciprocating weight W, which moves with the crosshead and a revolving weight L, which is concentrated at the crank pin axis.

That if r denotes the crank arm radius (equal to one-half the stroke) and θ the angle made by the crank radius with the direction of the cylinder axis, we have for a vertical engine an unbalanced force denoted by Q, due to the reciprocating weight W, and unbalanced vertical and horizontal forces denoted by V and H, due to the revolving weight L. If R denotes revolutions per minute, the expressions for Q, V, and H are as follows:—

$$Q = .000341\, rR^2 W \left\{ \cos\theta + \frac{\cos 2\theta}{n} \right\} \dagger$$

$$V = .000341\, rR^2 L \cos\theta.$$

$$H = .000341\, rR^2 L \sin\theta.$$

Formulæ for Forces and Moments in Multi-Cylinder Engines.

8. Suppose, now, we have k parallel cylinders of

*Omitted.

†In this equation n equals the ratio of connecting rod to crank lengths.

equal stroke directly connected to the same shaft. Suppose that their axes are distant l_1, l_2, l_3,...l_k feet, respectively, from a fixed point on the shaft. Suppose their cranks are set at angles a_1, a_2, a_3,...a_k with a fixed radius of the shaft. Let w_1, w_2, w_3,...w_k denote the reciprocating weights, L_1, L_2, L_3 . . . L_k the revolving weights, r the common crank arm, R the common revolutions per minute, and θ the angle made by the fixed shaft radius (from which a_1, a_2, etc., are measured) with the plane through the axes of the cylinders.

We need to determine the total or resultant unbalanced forces set up because of the rotation of the engine. Since the unbalanced forces in the various cylinders are not all in the same line, unbalanced moments will also make their appearance, and these, too, we need to determine.

Consider, first, the reciprocating weights. Denote the unbalanced forces due to them in the respective cylinders by q_1, q_2 . . . q_k. Evidently from the results demonstrated in Appendix A we have:—

$$q_1 = .000341\ rR^2w_1 \left\{ \cos(\theta + a_1) + \frac{1}{n} \cos 2(\theta + a_1) \right\}.$$

Similarly we have

$$q_2 = .000341\ rR^2w_2 \left\{ \cos(\theta + a_2) + \frac{1}{n} \cos 2(\theta + a_2) \right\},$$

and so on. It is convenient in determining the complete effect of the forces to use the ordinary device of applying, at the point through which moments are taken, two equal, opposite and parallel forces for each unbalanced force considered. Each unbalanced force is thus reduced to a force acting through the point about which moments are taken, and a couple whose arm is the distance from the point about which moments are taken to the line of action of the unbalanced force. If we take moments about O and denote the moment of the couple, due to w_1 by m_1 we have:—

$$m_1 = q_1 l_1 = .000341\ rR^2 w_1 l_1 \left\{ \cos(\theta + a_1) + \frac{1}{n} \cos 2(\theta + a_1) \right\}$$

$$m_2 = q_2 l_2 = .000341\ rR^2 w_2 l_2 \left\{ \cos(\theta + a_2) + \frac{1}{n} \cos 2(\theta + a_2) \right\}$$

and so on.

The expression .000341 rR^2 common to all our formulae may be conveniently replaced by C.

It is also convenient at this stage of analysis to separate the forces into two parts. That part varying as cos $(\theta + a)$ is conveniently called the primary force, and that varying as cos 2 $(\theta + a)$ is conveniently called the secondary force. Corresponding to the primary and secondary forces we have similarly the primary and secondary moments. Let Q_1 denote the resultant primary force due to all the cylinders. Let Q_2 denote the resultant secondary force due to all the cylinders. Let M_1 denote the moment of resultant primary couple due to all cylinders. Let M_2 denote the moment of the resultant secondary couple due to all the cylinders. The forces being considered are all parallel, being those due to reciprocating weights, and their resultants are readily written down from well-known principles of mechanics.

INTRODUCTION OF GRAPHIC METHODS.

9. From the above somewhat formidable looking expressions it is possible to calculate the resultant unbalanced forces and moments of unbalanced couples due to any known system of cylinders at any point of the revolution of the shaft. These expressions, however, are entirely too complicated to be of much value when the investigation of measures of amelioration is undertaken. Fortunately, the case is one to which graphic methods are peculiarly adapted.

Referring to Fig. 1 Ox is the direction of the cylinder axes $xOA=\theta$. Draw OC_1 parallel to crank No. 1 and such that to a suitable scale $OC_1 = w_1$. Similarly draw OC_2, OC_3, OC_4, representing in direction and length the other cranks and reciprocating weights. Four cylinders are represented in the figure, but the process is applicable to any number.

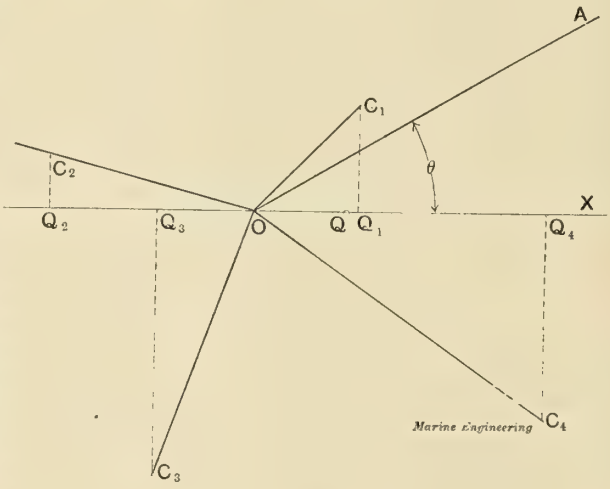


FIG. 1.

Draw the perpendiculars C_1Q_1 C_2Q_2, C_3Q_3, C_4Q_4.

Evidently $OQ_1 = w_1 \cos(\theta + a_1)$

$OQ_2 = w_2 \cos(\theta + a_2)$, and so on.

The algebraic sum of OQ_1, OQ_2 . . . OQ_4 is OQ, which then represents in magnitude and direction the resultant primary force.

Referring now to Fig. 2, instead of drawing all the cranks from O draw Ox and OC_1 as before. Then from C_1 draw a line C_1C_2 parallel to the second crank and representing in length its reciprocating weight. Draw from C_2 a line C_2C_3 similarly representing the third crank, and from C_3 draw C_3C_4 for the fourth crank. Drop the perpendicular C_4Q upon Ox, and OQ in Fig. 2 is exactly the same as OQ in Fig. 1, $OC_1C_2C_4$ in Fig. 2 is called the primary force polygon, and the angle β or AOC_4 is constant, whatever the value of θ. Evidently, if for OC_1, OC_2, and so on, we substitute a single crank at the angle β with OA, driving a reciprocating weight, represented by the length of OC_4, then, as regards primary reciprocating forces, the single weight on the single crank is equivalent to the system of four weights on four cranks from which it was deduced. The line OC_4 is called the closing line of the primary force poly-

gon. Clearly, if there were a fifth crank in the combination, parallel to C_4O and driving a reciprocating weight represented by the length C_4O, there would be no resultant primary force at any point of the shaft's revolution. In other words, the engine would be perfectly balanced as regards primary force.

In practice, when drawing a primary force polygon, it is convenient to make OA correspond with a crank radius, and measure all other crank angles in the direction of rotation from the direction of this crank. I usually use the forward crank radius as the direction to which to refer all angles.

Exactly in the same manner as the primary force polygon has been determined, it is possible to determine and delineate a primary couple or moment polygon, and the secondary force and couple polygons.

In drawing the secondary force polygon the weights are, of course, $\frac{I}{n}$, those used in the primary force

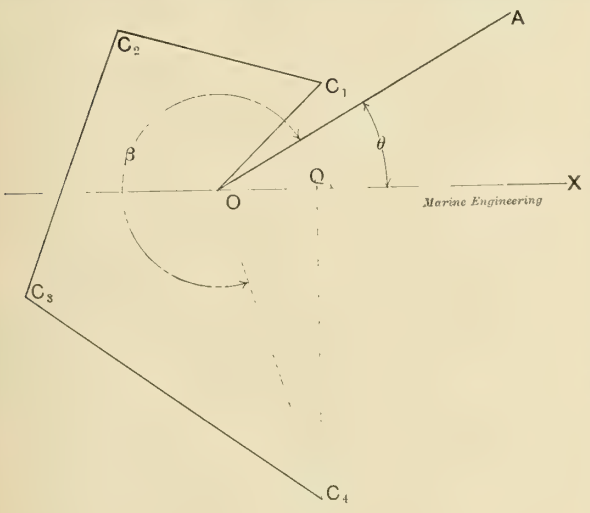


FIG. 2.

polygon, and the angles are doubled. This involves drawing angles greater than 360 degrees, which can, of course, be readily done.

When it comes to the couple or moment polygons, the lengths of the sides represent the moments of the couples, or the products w_1l_1, w_2l_2, etc. It is necessary, when considering actual engines, to choose a convenient point from which to measure l_1,l_2, etc., or, in other words, about which to calculate the moments of the couples. I find it convenient to use the point where the after cylinder axis intersects the shaft axis.

TREATMENT OF REVOLVING WEIGHTS.

11. So much for the reciprocating weights. The forces due to them are all parallel to the cylinder axes —vertical in the case of a vertical engine and horizontal in the case of a horizontal engine. When, however, we consider revolving weights, we find that, for a single weight L, the forces V and H, parallel and perpendicular, respectively, to the cylinder axis, are given by the formulae:—

$$V = CL \cos \theta$$
$$H = CL \sin \theta.$$

Where, as before, $C = .000341 \pi R^2$.

It is to be noted that these revolving forces are altogether primary. When proceeding from the case of a single cylinder to that with a number of cylinders acting on one shaft, the steps in connection with revolving weights are exactly the same as for reciprocating weights, and lead us to force and moment polygons for the revolving weights, both of which are primary only. It is to be noted that the closing line of a force polygon for revolving weights represents a revolving weight.

MINOR OR SECONDARY WEIGHTS.

12. I have now shown how to determine completely the resultant unbalanced forces and moments, at any point in the line of the shaft, due to any number of cylinders, their pistons, connecting rods, etc.—what may be called the main weights of the engine. There are, however, other moving weights which it is necessary to take account of—such as the valves, air pump gear, bilge pump gear, when fitted, etc.

In Appendix B, I have described and shown in detail methods of handling typical weights—valve gear, etc.—and it is believed that a careful study of the methods applied in Appendix B will enable the student to determine proper results in any ordinary case. There is no satisfactory method for handling radial valve gears, because such gears do not give harmonic motion. The most satisfactory method for such gears is to determine an approximate harmonic motion for them and work with that. The exact method is, of course, to determine graphically the motion of the valve, and then its velocity and acceleration; but even after this is done we are unable to satisfactorily balance such gears with weights which have harmonic motion.

CONDITIONS ESSENTIAL TO BALANCE

15. I come now to the question of balancing engines so as to reduce or extinguish entirely unbalanced forces. The methods previously explained will always enable us to determine whether or not an engine is balanced, and modifications of them will be found very useful when searching for methods to obtain a balance. I shall consider, primarily, the usual type of marine engine, the "vertical inverted," where the cylinders are arranged in line above the shaft. There are four conditions which must be fulfilled in a perfectly balanced engine.

First. As it revolves the combined center of gravity of the moving reciprocating weights must remain at a constant distance from the axis. When this is the case there can obviously be no resultant inertia forces, and hence no external force caused by the motion of the reciprocating weights.

Second. If we substitute for each moving reciprocating weight another one proportional to the product of the weight by its distance parallel to the shaft from a fixed point on the shaft axis, the center of gravity of this derived system of weights must remain at a constant distance from the axis as the shaft revolves.

When this is the case and the first condition is complied with, there can be no external couple due to reciprocating weights.

Third. The center of gravity of all revolving weights must be in the shaft axis.

When this is the case there can be no external force due to revolving weights.

Fourth. If for each revolving weight we substitute a weight proportional to the revolving weight, multiplied by its distance parallel to the shaft from a fixed point on the shaft axis, the center of gravity of this derived system must be in the shaft axis.

When this is the case and the third condition is complied with, there can be no couple or moment from revolving weights.

The above essential conditions for perfect balance have been known for years. It is evident that if all the force and moment polygons, as explained by me, are closed, the four conditions are fulfilled—otherwise, they are not fulfilled. It is evident, too, that if the four conditions are fulfilled for uniform rotation, they are necessarily fulfilled for non-uniform rotation.

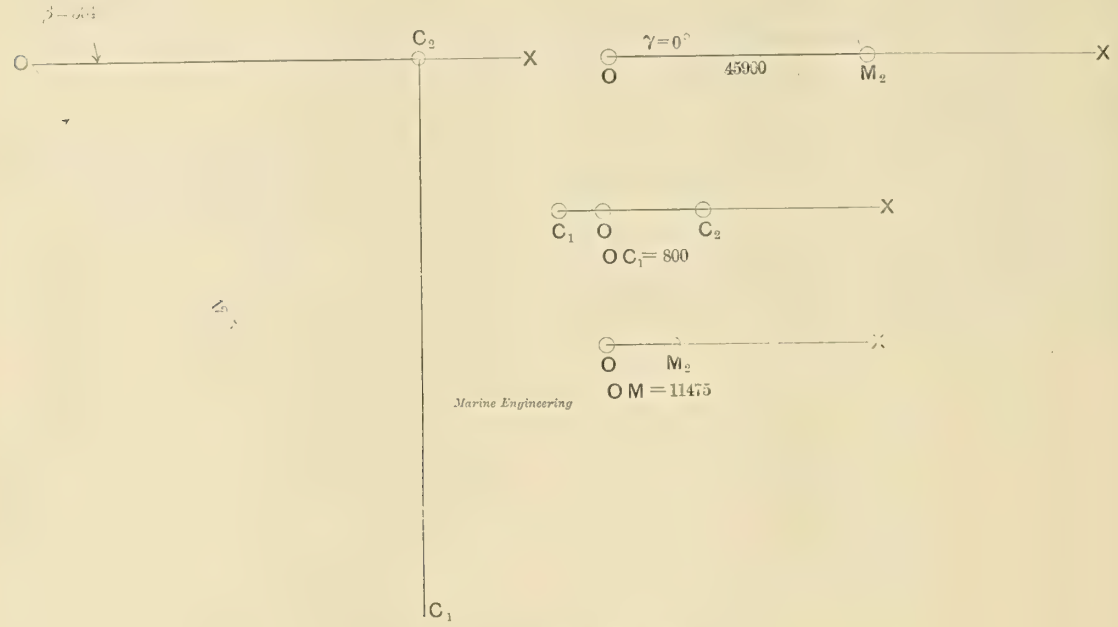


FIG. 3, CHARLESTON POLYGONS.

FORCE AND MOMENT POLYGONS FOR ACTUAL NAVAL ENGINES.

17. It is evident from what has gone before, that the more sides to our force and moment polygons the more readily they can be closed by manipulating weights and crank angles. That is to say, the more numerous the cranks of an engine the more readily it can be balanced without using special balance weights, which should be avoided where practicable. Also, for

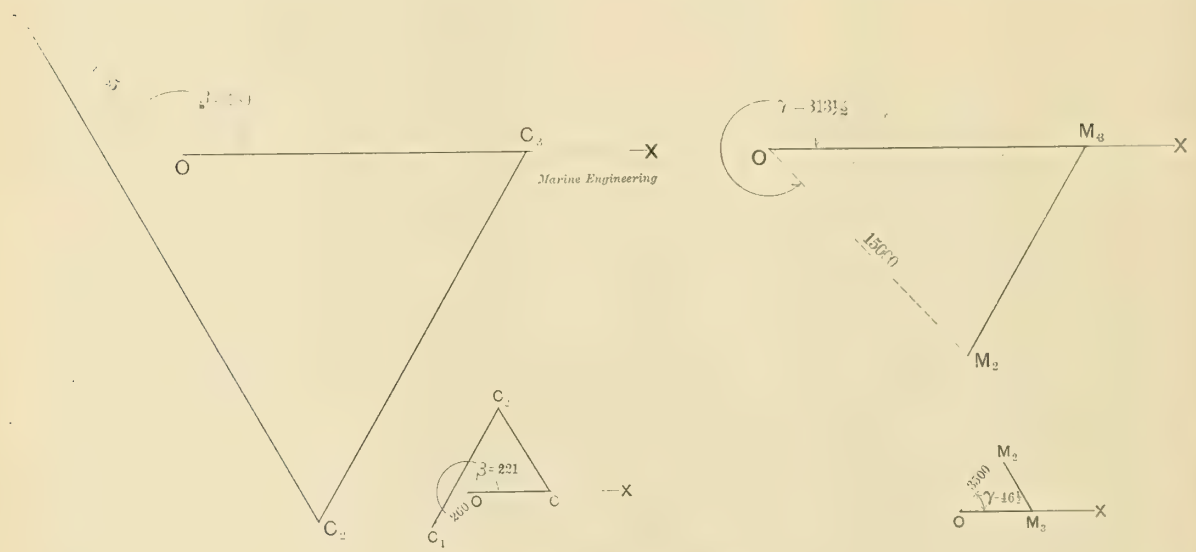


FIG. 4, YORKTOWN POLYGONS.

an engine of given power and revolutions per minute, the more numerous the cylinders the lighter the moving parts of the individual cylinders.

Perhaps this can be better appreciated from examination of Figs. 3, 4, 5 and 6. These give the primary and secondary force and moment polygons for the reciprocating weights of four United States naval vessels. The particulars needed in determining these polygons are given in Table IV., below. The *Charleston* referred to is the first steel cruiser of that name, which was wrecked a year or two since. The polygons of Figs. 3 to 6 are drawn on very different scales for the various vessels. If drawn on the same scale for all four, the differences in actual size would be startling.

After making due allowance for the fact that the engines develop different powers at different revolutions, the ameliorative effect, as regards vibrations, of increase in the number of cylinders is obvious.

RANGE OF DISCUSSION TO BE UNDERTAKEN.

18. I shall proceed now to discuss the question of balancing ordinary vertical inverted engines of 1, 2, 3, 4 and 5 cranks. As a rule, there is one cylinder to each crank, and this is assumed to be the case unless otherwise stated. Main weights only will be considered at first.

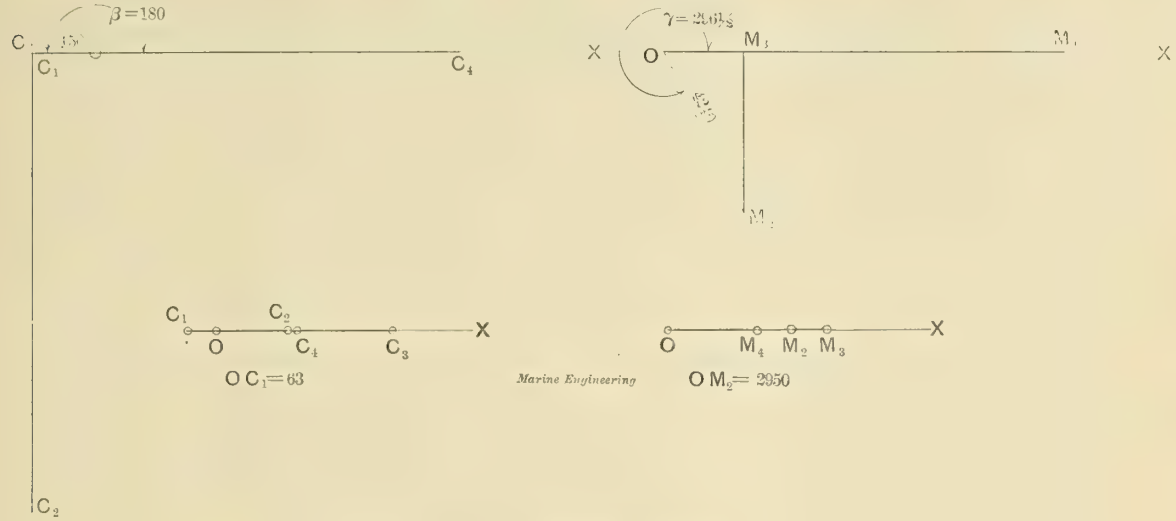


FIG. 5. VESUVIUS POLYGONS.

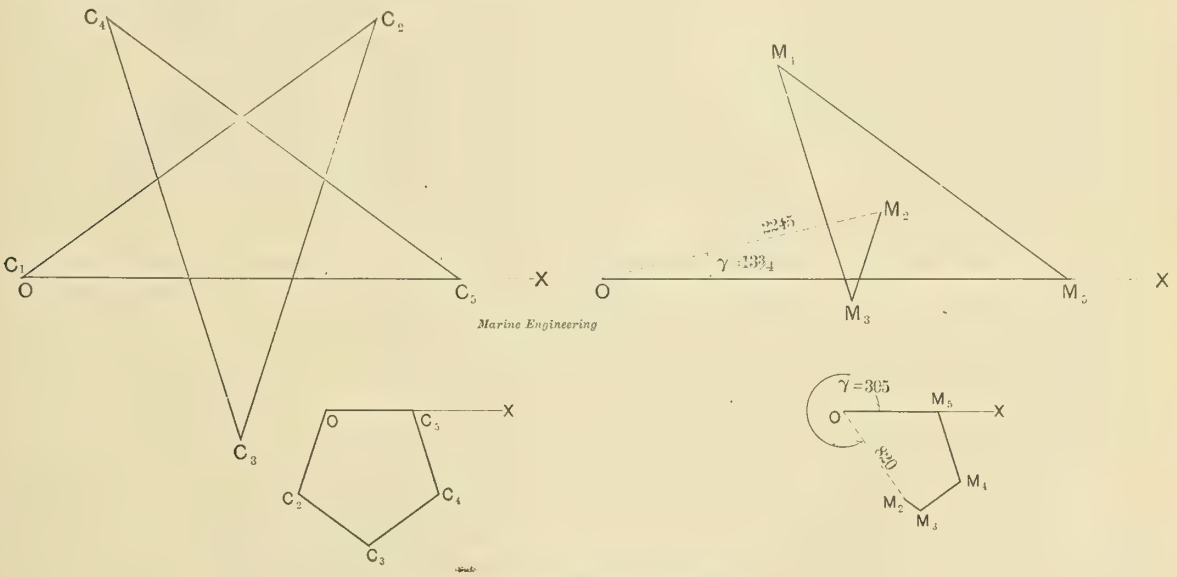


FIG. 6. CUSHING POLYGONS.

ENGINES WITH ONE CRANK.

19. In Appendix A* the resultant forces due to the inertia of moving parts of a single-crank engine are fully determined. With one cylinder there are no unbalanced moments, and partial or complete balance

*Omitted.

cannot be obtained by judicious arrangement of moving parts of several cylinders. It is possible to balance the primary reciprocating forces by introducing large revolving weights, but the strong objections to this course have already been pointed out. It is, however, practicable to balance completely the revolving weights by weights on the shaft opposite the crank pin, and this should always be done. If it is then required to balance the reciprocating weights, the most practicable method is to use lever driven balance weights, one arrangement being shown diagrammatically in Fig. 7. The introduction of such a weight evidently results in an unbalanced couple. If this must be avoided, two weights may be used, as indicated in Fig. 8. It is to be observed that, in the case of a single-cylinder engine with an air pump driven by a lever from the crosshead, the reciprocating air-pump weights partially balance those of the cylinder, and by making them of the proper weight complete balance

FIG. 7, SINGLE CYLINDER BALANCE BY SINGLE RECIPROCATING WEIGHT.

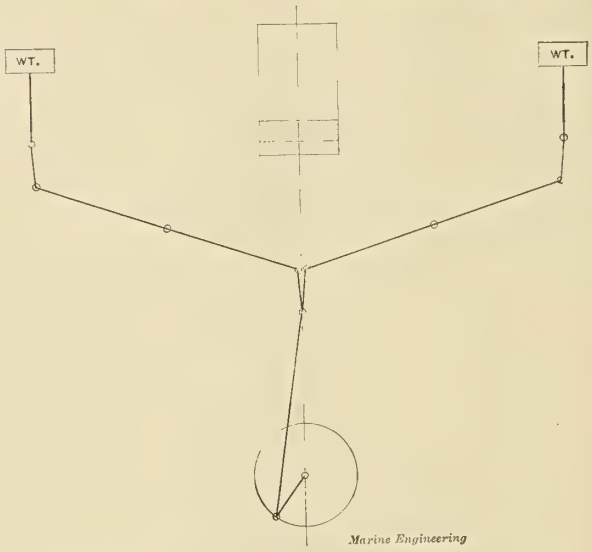


FIG. 8, SINGLE CYLINDER BALANCE BY DOUBLE RECIPROCATING WEIGHT.

may be obtained. But then the air pump weights would be impossibly heavy. The small use now made of single-cylinder engines for marine purposes renders the question of the balance of such engines one of little practical importance.

ENGINES WITH TWO CRANKS.

20. Typical force and moment diagrams for the reciprocating weights of a two-crank engine are found in Fig. 3 for the United States Steamship *Charleston*.

It is entirely impossible to close either force or moment polygons of two crank engines without introducing other sides, i. e., with the two-cylinder engine as usually arranged bob weights must be used to improve the balance. But these must be driven by cranks or their equivalents—eccentrics—resulting in an engine with more than two cranks.

It is probably the best practice, if two-crank engines must be balanced, to secure revolving balance by balance weights opposite each crank, and then for reciprocating balance use lever balance weights for each cylinder, as in the case of a single-cylinder engine. There are special arrangements, however, for two-cylinder engines, which secure perfect balance, though the usual arrangement of two cranks at 90 degrees must then be departed from.

Fig. 9 shows a perfectly balanced two-cylinder arrangement. The cranks are 180 degrees apart, and the cylinders have their axes in line and on opposite sides of the shaft. It is necessary in practice to use a double connecting rod and double crank for one cylinder, these being in each case of the same total weight as the corresponding parts for the other cylinder. Of course, too, the reciprocating parts of each cylinder must be of the same weight. It is obvious on inspection that this engine fulfils the four conditions for balance as regards forces set forth above, since, as the shaft revolves, the center of gravity of the moving weights does not change. Also, since the two cylinders are in line, there are no moments developed. The arrangement of Fig. 9 is not applicable to marine engines. It is used for fan and automobile engines. To

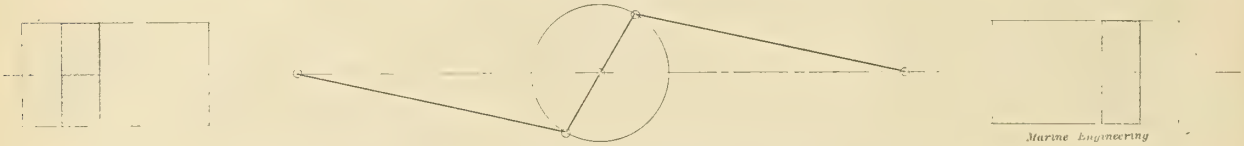


FIG. 9, DOUBLE CYLINDER ARRANGEMENT COMPLETELY BALANCED.

save expense, steam supply complications, etc., the arrangement shown in Fig. 10 is often adopted, even where that of Fig. 9 could be introduced, and it is used for small marine engines where Fig. 9 is not applicable. Fig. 10 is often considered equivalent to Fig. 9, but such is far from being the case. A couple is introduced, since the two cylinder axes are not in the same line, and the arrangement is the worst possible for secondary forces. Consider an engine where the connecting rod is four cranks long, for instances. The

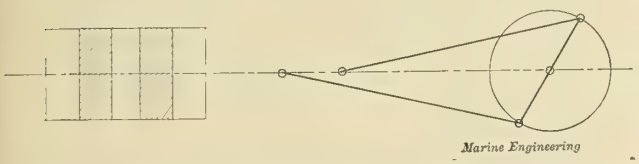


FIG. 10. DOUBLE CYLINDER ARRANGEMENT CRANKS AT 180 DEGREES.

primary reciprocating force is abolished if the moving parts are made of the same weight, but, as the secondary forces are added to one another, we have an unbalanced secondary force equal in amount to that due to half of one reciprocating weight.

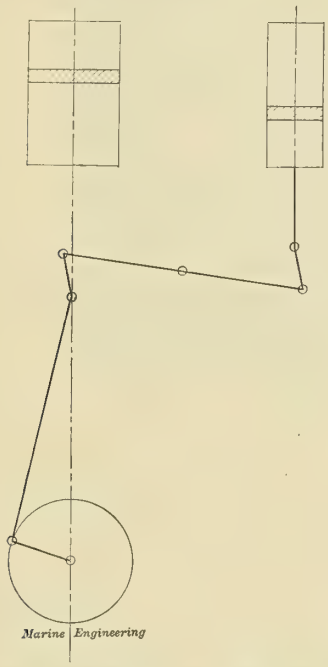


FIG. 11. MAC ALPINE'S BALANCE FOR TWO CYLINDERS.

When we consider revolving forces, the arrangement of Fig. 10 is objectionable only in the introduction of an unbalanced moment. The primary forces are neutralized as for the reciprocating weights, and there are no secondary forces from revolving weights. If the most complete revolving weight balance is wanted, however, the revolving weights for each crank must be separately counterbalanced.

The arrangement of Fig. 10 is a decided improvement, as regards vibrations, over the customary arrangement where the cranks are at 90 degrees. But the latter is preferable from certain practical considerations; for instance, it has no dead center, and gives a much more uniform turning moment.

MAC ALPINE'S TWO-CYLINDER BALANCE.

21. A two-cylinder arrangement has recently been brought forward by MacAlpine, which is superior to that of Fig. 10 in that it eliminates secondary forces. It is shown diagrammatically in Fig. 11. It gives perfect balance as regards reciprocating weights, and its unbalanced couples are athwartships instead of fore and aft, and are not likely to cause objectionable vibration. This arrangement has the practical objections mentioned above to that of Fig. 10, and a few others of its own, due to increase in number of working parts, use of rocking levers, etc. It is, however, a simple and elegant solution of the problem of complete two-cylinder balance, and by doubling it, i. e., using two pairs of cylinders on one shaft, it can be applied to triple and quadruple expansion engines.

ENGINES WITH THREE CRANKS.

22. For three-crank engines the force polygons are three-sided figures and the moment polygons two-sided figures. (See Fig. 4, giving the polygons for the Yorktown three-crank engines.)

We have now reached a sufficient number of cranks to allow reduction of unbalanced forces by properly choosing reciprocating weights and crank angles. Also, in these days of triple expansion, all marine engines of importance have at least three cylinders, so the three-crank case is the first one I have discussed of practical importance.

The moment polygons—two-sided figures—obviously cannot be closed by variation of weight and crank angles. The force polygons are, however, three-sided figures, and as long as any two of the reciprocating weights are together greater than the third, the primary force polygon can be made a closed triangle by adopting proper crank angles. The condition that two weights must be greater than the third allows a wide choice of reciprocating weights and cranks angles, and we should make a choice which will, if possible:—

1. Secure balance of secondary as well as primary forces.

2. Be desirable, or at least not objectionable, as regards the very many considerations other than vibration affecting engine design.

Now if all the reciprocating weights are made equal, and the three cranks set at 120 degrees, we find that—

1. The primary force polygon is a closed equilateral triangle.

2. The secondary force polygon is also a closed equilateral triangle.

3. The crank angles are those fixed upon by common consent as the most desirable from the many considerations other than those of balancing.

If it is desired to secure reciprocating weight balance as regards moments for three-crank engines, the most feasible plan is to introduce reciprocating balance weights at the ends of the engine driven by cranks or eccentrics. Such an arrangement, however, is in the four or five-crank class.

Considering now revolving weights, it is obvious

that if the revolving weight on each crank is equal (cranks being at 120 degrees), forces are completely balanced, while there is left an unbalanced revolving moment, which is, from the nature of the case, smaller than the unbalanced reciprocating moment. For this reason, it is not necessary as a rule to attempt further revolving balance in a three-crank engine with cranks at 120 degrees and equal revolving weights on the cranks, which is, by the way, the usual arrangement, all three cranks and connecting rods being made the same. If complete revolving balance is aimed at however, for moments as well as forces, the most feasible method is to counterbalance separately the revolving weight on each crank. Or the methods of revolving balance described in discussing four-crank engines may be applied.

ENGINES WITH FOUR CRANKS.

25. For a four-crank engine the force polygons are four-sided figures and the moment polygons three-sided figures.

Evidently, then, the "balancing possibilities," so to speak, in the case of a four-crank engine, are decidedly superior to those of engines previously considered. The large and increasing use, of late years, of triple-expansion engines with two low pressure cylinders, and of quadruple expansion engines, has, through the use of four cranks, increased the opportunities for balancing and the development of balanced types of engines.

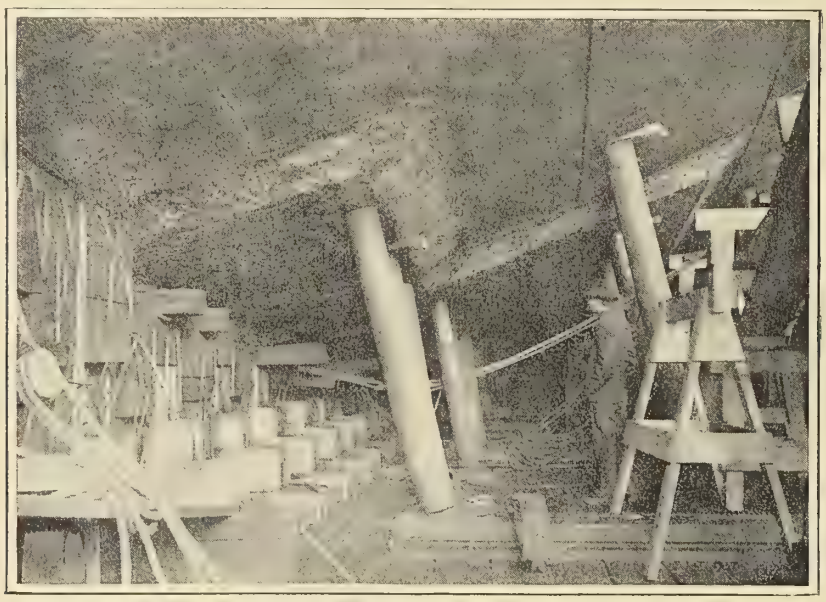
Progress in marine engine balance during the last ten years has been made almost entirely with four-crank engines. It is necessary, then, to consider most thoroughly the balancing possibilities and limitations of such engines.

SPACING OF FOUR CRANKS FOR BEST TURNING MOMENT.

26. Before beginning this task, I desire to call attention to the important fact that the usual spacing of cranks of 90 degrees, found in the case of four-crank engines, is essentially inferior as regards uniformity of turning moment.

If a four-crank engine has four simple, double-acting cylinders, the 90 degree spacing is equivalent, as regards turning moment, to two cranks at 90 degrees. For the turning moment on a crank at 0 degrees in such an engine is the same as that on its opposite crank at 180 degrees, and the two cranks at 90 degrees and 270 degrees are equivalent to one crank with double moment at either 90 degrees or 270 degrees. To secure the most uniform turning moment for double-acting engines, the crank should be at or opposite the angles obtained by dividing 180 degrees, not 360 degrees, by 4, the number of cranks. Thus, starting with the first crank at 0 degrees, the second should be at 45 degrees, or 225 degrees; the third at 90 degrees, or 270 degrees; and the fourth at 135 degrees, or 315 degrees. This conclusion, obvious for four-crank simple engines, is readily shown to apply to quadruple engines, where about the same power is developed in each cylinder. We shall see later that the crank angles for four-crank engines, which it is necessary to adopt for balancing, approximate fairly closely to those most favorable for uniform turning, so that a balanced four-crank engine is also one with a more uniform turning moment than if the 90-degree crank spacing is adopted.

(*To be continued.*)



PATCH ON THE BOTTOM OF THE BATTLESHIP OREGON.

The Accident to the Oregon.

The battleship *Oregon* is at present undergoing very extensive repairs in Puget Sound Navy Yard as a result of striking an uncharted reef on her way from Japan to Taku during the recent Chinese war. For six days she was fast on the rocks and during the rising and falling tides and the thrashing of the sea her bottom was broken into and injured in many places. After being successfully floated off, she was taken to Japan

and drydocked at Nagasaki, where temporary repairs were made which enabled her to remain in service for many months.

The illustration above shows the patch put on by the Japanese workmen over the principal injury where the outside plating was forced up and through the inner bottom, a distance of about 4 feet. The injured hull was covered with a large patch which covered the center line of the vessel and extended over about 700 square feet. The patch was made up by planking the hull in the way of the injury with timbers 14 by 14 inches placed in a fore and aft direction, with a layer of planking 3 by 12 inches placed transversely across the timbers. The planking was caulked and made water-tight, all bolted through and through, and the edges beveled to reduce the friction. Outside of this was fitted a patch of fifteen pound plates, riveted to the hull and caulked, making an independent water-tight patch over the wooden work.

On the inside of the ship, in the way of this injury, the double bottom was filled in with brick and cement work, which was as solid as a rock.

This work of docking and repairing the *Oregon* at Puget Sound is being done under the direct supervision of naval constructor Frank W. Hibbs, U. S. N. The ship was floated into drydock on October 25, 1901. The work of docking her and shoring up the heavy weights of armor and guns, so that the injured portions of the keel and plating might be removed, was one requiring exceptional care. None of the heavy guns or armor was taken off, but the ship was stiffened as much as possible in order that the blocks supporting the keel might be taken out to allow replacing the twisted and torn steel keel and shell plates.

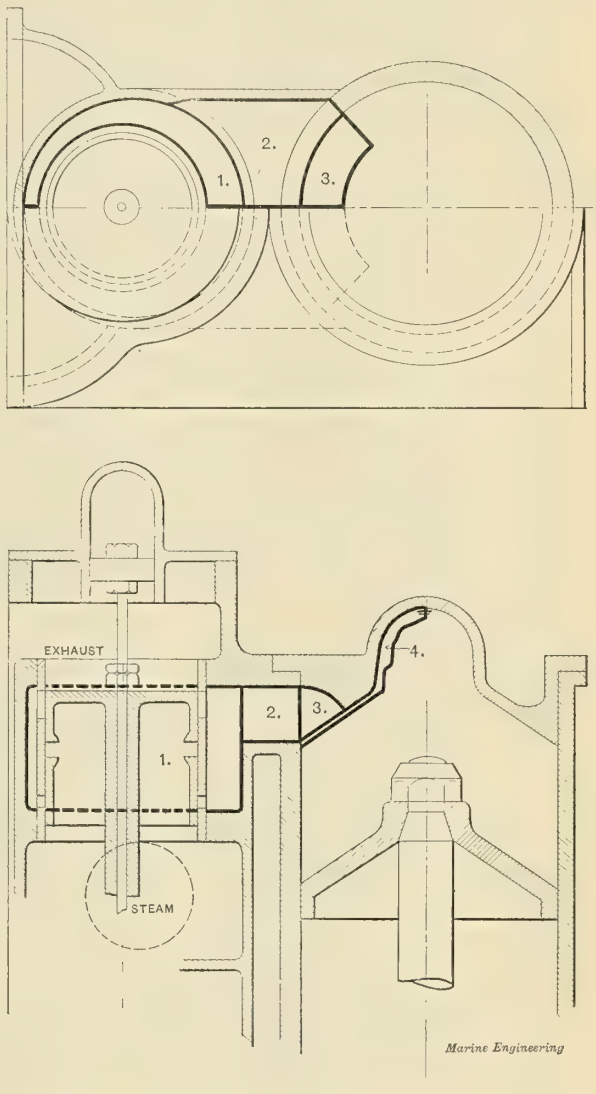
The stiffening was placed in the interior of the vessel in the shape of trusses and shores formed of Oregon pine timbers, 14 by 14 inches, and fitted between the decks and bulkheads in such a manner as to carry the weight outboard as far as possible and thence down to the bottom of the dock by means of cribs and heavy shores, 14 by 14 inches, placed 24 inches apart, and capped by two timbers of the same dimensions running lengthwise around the fore body of the vessel. These timbers were secured to the ship's sides by means of through bolts running through the frames of the vessel, and the top sides of the timber rested on the flange of a 5 by 5 inches angle, also riveted to the hull, below the line of the armor belt. A system of truss work on the inside was fitted on every third frame and with the outside shores formed practically a wall of timber. In this manner the ship was supported while the keel blocks were removed, and, although observations were made daily, no visible sign of sagging of the vessel was noticeable. The cut is reproduced by permission from *Leslie's Weekly*.

Annual Convention of the M. E. B. A. — The annua convention of the Marine Engineers Beneficial Association opened in Washington on Monday, January 20, and lasted nearly through the week. All of the old officers were re-elected for the ensuing year. Many important questions were discussed and the association was reported to be in a more prosperous and satisfactory condition than ever before.

The Calculation of Clearance Volumes.

BY HORACE HOLDEN THAYER, JR.

If the performance of an engine on trial under any given set of conditions is to be ascertained, the amount of clearance, or volume in the cylinder between the piston at either end of its stroke and the steam admission valve should be known. It is sometimes possible to measure this volume by plugging up any openings



ILLUSTRATING METHOD OF CALCULATING CLEARANCE VOLUMES.

which may be in the cylinder and valve chest and filling the cylinder with water or oil. If done in the machine shop the valve openings in particular have to be plugged, and on subtracting from the volume measured the piston displacement and the volume of the piston and piston rod, or volume of the piston, piston rod and tail rod, when the latter is used, we have a measure of the clearance of both ends. If done when the engine is in place on the boat, these deductions do not have to be made, and the clearance at either end may be found independently. In the latter case

the question of leaky valves has to be met, and in either case it is often difficult to enter the clearance space at a level high enough to allow of completely filling it. The only resort from these difficulties is to make a detailed calculation from drawings. This may seem to be a tedious and only roughly approximate method, but it can be used to obtain quickly accurate results.

Suppose a modern high speed triple expansion engine with piston calves has to be dealt with. The figure shows an outline of part of a cylinder and valve chest of such an engine, with the clearance volumes heavily outlined. In this case it is best to divide the volume to be ascertained into four parts, as shown,—(1) the chamber around the valve, (2) the lead to the head of the cylinder, (3) the opening in the cylinder wall, and (4) the space between the cylinder head and the piston when the latter is at the end of the stroke.

With a planiméter the area of (1), shown in the sectional plan, is measured, and the volume thus readily ascertained. Allowances can be made, if desired, for openings in the valve ring, also deductions for any webs, staybolts, etc., which may be in the chamber. Volume (2) is obtained in like manner. To obtain volume (3) the center of gravity of the section shown in the elevation has to be determined. This is best done by outlining it in some way upon stiff cardboard. The plan shows the circumferential length of cylinder wall cut away, and assuming that the section taken travels from one end of the opening to the other, we can measure the length of the arc traveled by its center of gravity. Then the volume is found by use of the theorem of mechanics that the volume of a solid of revolution generated by a plane figure, lying on one side of the axis, is equal to the area of the figure multiplied by the length of the path of its center of gravity.

The same method can be used for volume (4). The inside half-outline of the cylinder is traced and then at a distance from it equal to the linear clearance of the piston, its corresponding half-outline. The area and center of gravity of the space thus outlined are ascertained, and then the volume, the path of the center of gravity being a complete circle. There may be small additions for drain cocks, etc., but these in general will be insignificant, and in any case can be readily computed.

This method of calculating the clearance volume allows of independent calculations for the two ends of the cylinder, may be carried to as high a degree of accuracy as is desired, and with slight change is readily applicable to any desired case.

Bulkhead Doors.— In the express steamer, *Kronprinz Wilhelm*, of the North German Lloyd Steamship Company, the lower parts of the bulkheads are equipped throughout with a system of water tight doors which may be controlled either from the bridge of the ship or from the bulkhead itself. The system was invented by Prof. Dörr, and the company states that it will equip all of its steamships with this system. A demonstration was recently given on board the *Kronprinz Wilhelm*, when all of the twenty doors below the water line were closed from the bridge.

Armored Cruiser King Alfred

The armored cruiser, *King Alfred*, one of four vessels building for His Majesty's navy, was launched from the Naval Construction Works of Messrs. Vickers Sons and Maxim, Limited, on October 28, and the accompanying illustrations show the ship on the ways as she was water-borne after the launching. At the time of the launching, the *King Alfred* had in place all of her side armor, the 2-inch nickel steel, the after barbette and the main deck casemates. Her launching weight was about 8,070 tons, but as the ways were of the unusual width of 6 feet 6 inches the pressure per square foot was reduced to 1,723 tons. The time taken by the ship from the first movement until she was floated was 59 seconds, and by means of the chain drags, which are shown in the illustration, and which weigh 400 tons, the hull was brought to rest 70 feet from the end of the ways.

These new ships resemble in many respects the *Powerful* and *Terrible*, but are great improvements over those cruisers. The general dimensions of the *King Alfred* are: Length, 500 feet; beam, 71 feet; load displacement, 14,100 tons; corresponding draft, 26 feet. The vessel carries 2,500 tons of coal, which will give her a steaming radius of 12,500 miles at 14 knots. A water line belt of armor with maximum thickness of 6 inches amidship and 4 inches at ends, and 11 feet 6 inches deep, extends along the sides of the ship and beside the machinery, boilers and magazines. At the after end of this belt a 5-inch armored bulkhead is fitted and 2-inch nickel steel protected plating is worked in on the bows, and aft of the screen bulkhead is a protective deck 2 1-2 inches thick, giving protection to the steering gear and after capstan. Within the citadel two protective decks are worked, the upper being 2 1-2 inches and the lower one 1 1-2 inches thick. The 9.2-inch guns are protected by two 6-inch barbettes, one forward and one aft, in addition to the gun shields, and the 6-inch guns have separate 5-inch armored casemates The conning tower is of 12-inch armor.

The main battery consists of two 9.2-inch Vicker's guns, giving a rate of firing of four aimed rounds per minute with a 380 pound shot, developing a muzzle energy of 17,830 foot-tons. There are also twelve 6-inch guns mounted in a series of two-storied casemates, four on either broadside, and so arranged that four can be fired directly ahead and four directly astern. There are also a large number of 12-pounder and machine guns. The total number of projectiles of the main and secondary batteries that can be fired ahead or astern is 116 per minute, with an aggregate weight of 5,720 pounds, while the broadside fire totals 11,190 pounds.

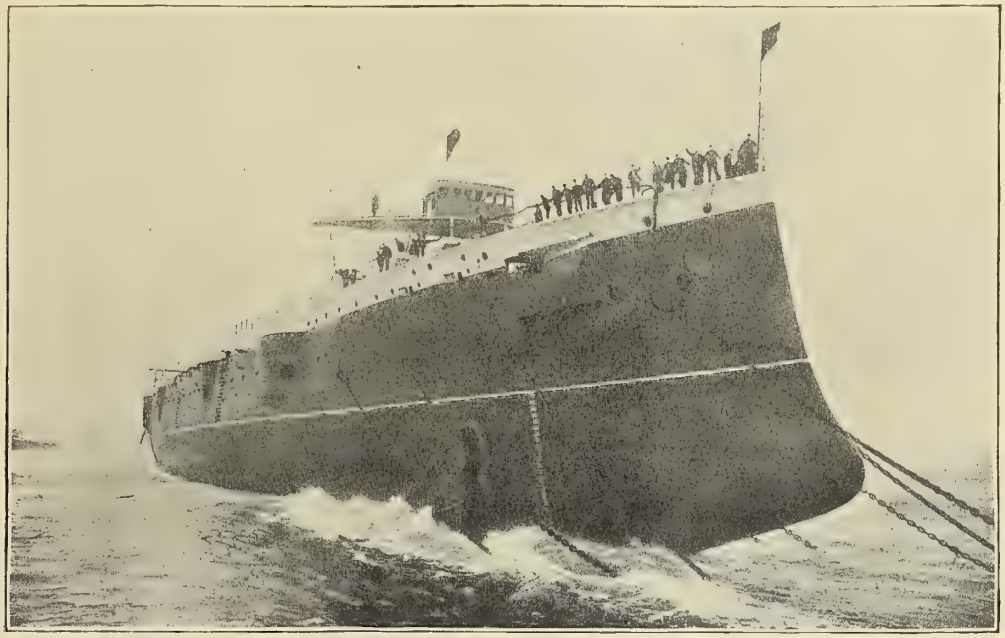
There are two sets of four cylinder triple expansion engines, each set developing 15,000 horse power. The diameter of the high pressure cylinder is 43 1-2 inches, that of the intermediate 71 inches, and that of the low pressure cylinders is 81 1-2 inches, all having a common stroke of 48 inches. There is one piston valve on the high pressure cylinder, two on each intermediate pressure cylinder, and double ported slide valves on the low pressure cylinders. All cylinders are steam jacketed. There are two gun metal con-

densers bolted to the back columns of each engine, and the collective cooling surface of the four is 32,000 square feet.

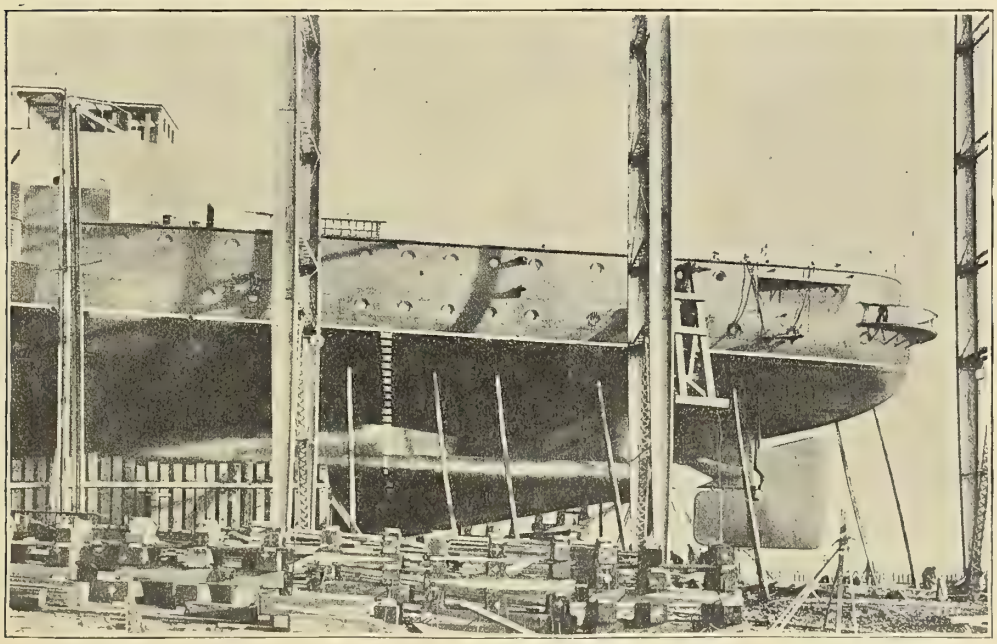
The air pumps are direct connected by levers to the main engines. Steam is supplied at a working pressure of 300 pounds by 43 water tube boilers of the Belleville economizer type, placed in four separate compartments. This enormous power is expected to drive the ship at a speed of 23 knots.

For the above facts and photographs we are indebted to *Engineering*.

Wireless Telegraphy. — Sig. Marconi has demonstrated the possibilities of wireless telegraphy by transmitting from Cornwall, England and receiving at St. Johns, Newfoundland, a distance of over 2,000 miles, repeated signals of the letter S. This work has been simply in the nature of an experiment, and upon the perfecting of the apparatus Marconi expects to transmit and repeat messages. The fact that wireless telegraphy can be operated from such great distances indicates either that the sea forms no barrier to the induction waves, or that they travel along the surface.



LAUNCH OF THE ARMORED CRUISER KING ALFRED.



STERN OF THE ARMORED CRUISER KING ALFRED SHOWING LAUNCHING CRADLE.

TOW BARGES AS GENERAL FREIGHT CARRIERS.

EDWIN B. SADTLER.

The history of barges such as are towed is very similar to that of canals, which are well known to have existed in the time of the early Egyptians and Chinese, for hundreds, if not thousands of years before the Christian era. Notwithstanding the great number of years that barges have been used, their greatest usefulness has only been developed in very recent years; in fact their era of expansion and development has just fairly begun.

While some very large barges have been used in European countries (the writer has seen barges over two hundred feet long and forty feet wide, in use on Russian canals) their use has not been as common as in the United States, where they have been used on rivers, canals and lakes as well as for sea towing. The sea towing is what we now propose to consider.

While this custom has been practised for some years, it was made possible and safe to carry it out on a large scale by the invention of the towing machine by Mr. T. Jackson Shaw, in 1888. This machine was patented by Mr. Shaw and Mr. John Spiegle, then superintendent of the Boston and Philadelphia Steamship Company, and first applied to the Boston Tow Boat Company's collier *Orion*, which, strangely enough, has been chosen to perform one of the most difficult feats of towing—that of taking the mammoth new floating dock for the United States Government from Sparrows Point, Md., to Algiers, La. This trip was successfully made in eighteen days, ending November 3, 1901, this enormous box-like craft having been towed nearly two thousand miles. One of the best examples of sea-towing is the Reading Railroad Company's large fleet, trading between Philadelphia and eastern ports. In this service a tug boat, or rather towing steamer of one hundred and seventy feet in length, with engines of about one thousand horse power, tows three, and at times four barges, of sixteen hundred tons capacity each, a distance of five hundred miles, and returns with empty barges in six and one-half days, maintaining a schedule that can be relied on except in extremely severe weather. The same company is now building barges of three thousand tons capacity and expect to tow two of these with one tug of the above size.

Barges of like capacity are now in use between Cuba and Philadelphia or Norfolk, and two additional barges of four thousand tons capacity each have just been ordered for this service. On the Great Lakes barges are now in use of from five to six thousand tons capacity each.

In these days of low freights, some improved methods must be used to make the transportation of coarse and non-perishable freights pay, and it is the belief of the writer that if long distance towing were properly developed it would result in large profits to those investing in this type of transportation. The economy of the system arises largely from the fact that the power being applied from a comparatively small vessel, a small crew is required, being seventeen men on the tugs referred to above. The barges having no machinery except pumps and small auxiliaries, require an extremely small crew, being usually five men to each barge. The greatest economy comes from keeping the tugs constantly employed, by having a sufficient number of tugs and barges, so that every time a tug comes to the end of the voyage she leaves her barges to be unloaded, and takes up a fresh tow already loaded and waiting for transportation.

The special types of both tugs and barges would, to a certain extent, have to be designed to meet the requirements of the particular service for which they were intended.

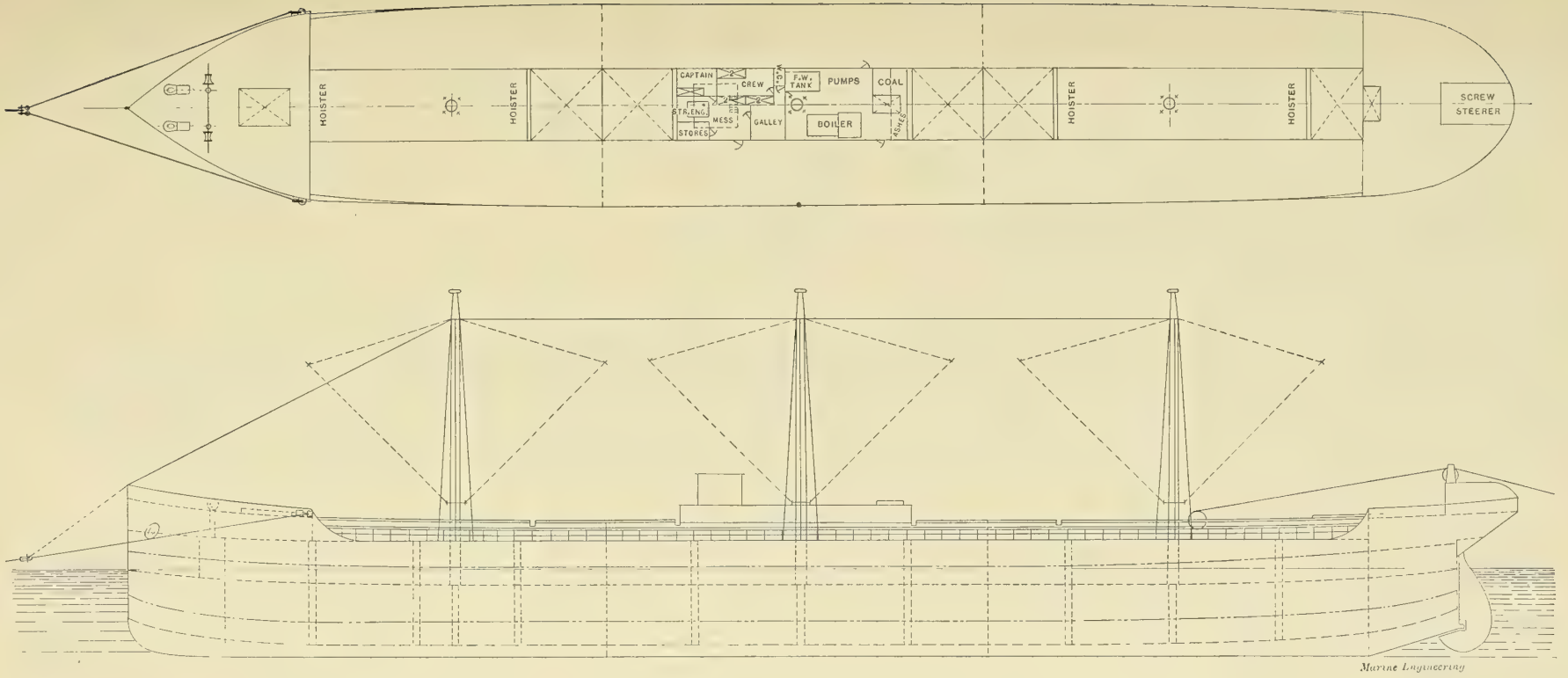
Being a firm believer in the possibilities of long distance towing I have prepared a sketch of a barge suitable for handling freight of a miscellaneous character, such as is handled by the Atlantic liners and coastwise trade. The principal characteristics of this vessel are as follows: The barge to be 300 feet long on the water line, 46-feet beam and 26-feet molded depth, having a trunk extending from forecastle to poop deck, forming the hatches, and between the hatches a cover for the hoisting engines. This trunk would be raised as shown between the third and fourth hatches, forming a house which would contain the crew's quarters and donkey boiler, pumps and steering engine. There would be a pilot house directly over this house. The three masts form derricks for the six hatches, the main mast also forming a stack for the donkey boiler. Simplicity of construction and few obstructions for the sea to strike would be the main features of this barge. As the crew would live amidships the space under the forecastle could be used for windlass engine, paint lockers, etc. The poop could be used for stores or freight, as desired. As barges are frequently difficult to steer the stern has been cut away and a balanced rudder of large size fitted. Both peaks would form ballast or trimming tanks.

In order to assist in keeping these barges on their course they are designed to be towed from a towing machine on the tug or barge ahead, the end of the hawser being shackled to a bridle attached to the sides of the vessel about forty feet from the stem, as shown on the sketch. This would have a tendency at all times to keep the barge straight in the wake of the tug. When two barges are in tow the hawser to the second would lead through a swivel chock on the stern of the first barge, which makes the hawser lead properly without serious side chafing when changing the course of the tow. These barges would each have a deadweight capacity of five thousand tons on twenty feet draft of water.

A tug or steamer 200 feet by 36 feet by 20 feet, closed in forward to the upper deck and having engines of about 1,700 horse power would tow two of these barges 3,200 miles in twenty and one-half days.

Taking into consideration interest on first cost of vessel, insurance, maintenance cost of crew, coal consumed, and in fact, all expenses entering into the use of vessels, it is found that the expense of the tug mentioned above would be about one hundred and fifty dollars per day, and the barges each about fifty dollars per day.

This outfit, to work at its most economical point, would, by allowing the tug to start on the return trip



TOW BARGE FOR OCEAN FREIGHT SERVICE.

after one-half day in port, taking up a tow already prepared, make a round trip in forty-two days.

The barges would be allowed nine days in port for unloading and reloading, when they would be taken in tow by a second tug, due at that time, which tug would leave her barges to be taken by the next tug and so on.

Working out this schedule completely it is found that for a trip of this length it would require three tugs and ten barges, which would have a capacity of transporting 900,000 tons per annum a distance of 3,200 miles, at a cost of 26 cents per ton.

As the prices for full cargoes of the cheapest class of freight, as shown by ships' charters reported in the daily papers, seldom run below two dollars per ton for this distance, it can readily be seen how very profitable this business would be. Should the service be such as to permit of larger units, a single barge could be used instead of two, which would still further reduce expenses of transportation.

The greatest objection to barge towing has been the reluctance of insurance companies to take the risks. This should and will be overcome in time, as experience has shown that it is possible to tow these barges past such places as Hatteras, and also that of the large number of barges lost each year, the majority of them are old, worn-out hulks, not fit to go to sea except under favorable circumstances. It is also notable that few, if any, barges specially designed for this service have ever been lost when towing behind a vessel equipped with a towing machine.

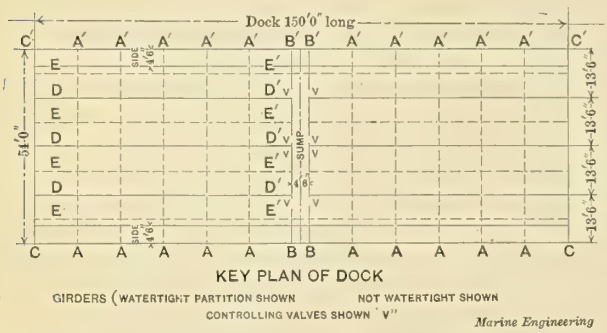
Wireless Telegraphy.—It is stated that the Channel fleet of Belgian mail boats will be equipped with wireless telegraphy installations. Experiences with this system have been carried on for many months by the company operating this fleet.

Floating Dock for Khartoum.

A floating dock has been designed for the Egyptian War Office for service in Khartoum, and from a complete description, with illustrations, which appeared in the London *Engineer*, we quote as follows:

Electricity is to be adopted for operating the pumping plant, and it was considered desirable that the boilers and generating plant should be on shore. The designs were required complete in every detail, so that with material supplied from England the dock could be constructed and erected by native labor at the site on the Nile.

Referring to the illustrations it will be seen that the lower portion of the dock consists of a pontoon 150 feet long by 54 feet wide, the depth varying from 3 feet 7 1-2 inches to 2 feet 10 1-2 inches. The two pontoons, forming the sides of the dock, are 150 feet long by 9 feet deep by 4 feet 6 inches wide. The dock bottom is divided into halves by a transverse sump 4 feet 6 inches wide. Each half is subdivided into four water tight compartments by longitudinal divisions. Each compartment discharges into, and is filled from the sump by means of a flap valve operated through a shaft and levers by the man in charge of the dock.



The sump is flooded by a 10-inch diameter sluice valve, and pumped dry by two 6-inch electrically driven centrifugal pumps arranged in duplicate, one on each side of the dock.

Each of the pontoons forming the sides of the dock is divided into twelve water tight compartments by vertical diaphragms, and there is sufficient buoyancy in the sides to support the dock, should the whole of the bottom compartment be completely filled.

The weights are as follows: Steamer, 200 tons; dock, 295 tons; machinery, 10 tons; timber packings, 37 tons; total, 542 tons. The draft of the dock is: (1) Unloaded, 1 foot 9 1-4 inches; (2) loaded, 2 feet 8 1-2 inches; (3) when passing under a steamer of 3 feet 6 inches draft, allowing 6 1-2 inches clearance, 9 feet 10 inches. Now, when passing under a steamer with a draft of 9 feet 10 inches, the weight of water displaced by the dock is 976 tons. The weight of the dock and machinery and the effective weight of the timber packings is 328 tons; hence the weight of the contained water is 976 — 328 = 648 tons. The quantity of water to be pumped is thus 648 tons. The holding capacity of the lower portion of the dock is 699 tons.

The sides of the dock are relied on to give longitudinal stiffness, and to them the weight of the ship, not directly water borne, is transferred by ten plate cross girders, two sump plate and two end girders. These cross girders are continuous, and the angles of the water tight partitions and other longitudinal girders are stopped off where they intersect. The cross girders are not water tight partitions, draining openings being provided. In each half of the bottom of the dock the water tight partitions form three longitudinal girders, and there are four other plate longitudinal girders not water tight partitions, but provided with drainage openings. To support the ship a teak bearer 10 inches wide and from 4 inches to 7 inches thick to allow for the camber of the deck is secured to the top of each longitudinal girder. On these, packing blocks, 10 inch by 10 inch by 2 feet long, are laid at intervals of about 6 feet to support 8 inch by 8 inch transverse bearers. The transverse bearers carry the 9 inch by 4 inch planks laid continuously, which support the flat bottom of the vessel.

To calculate the sectional areas of the dock sides, the vessel load of 200 tons was assumed to be evenly distributed over the middle hundred feet. This gives a bending moment of 625 foot tons, and a shear of 12 1-2 tons per side. If, however, the pontoons at one end of the dock are supposed flooded, others remaining empty, a maximum bending moment would occur about 16 feet to the right of the center line, and equal to 1,000 foot tons per side. The maximum shear would be 30.5 tons per side.

When designing the cross girders, the loading with the vessel was assumed as above, and the load on a cross girder was taken as uniformly distributed over the middle 27 feet. Greater bending moment arises, however, if the dock is supposed unloaded, and the outside pontoons completely flooded, the central pontoons being empty. This gives a maximum bending moment at the center of the cross girder of 124 foot tons. Taking the maximum draught of the dock at 10 feet, this head of water gives a pressure of 4.45 pounds per square inch on the under side of the dock. The stiffeners are 2 feet 1-4 inch pitch, and formed of 4 inch by 3 inch by 5-16 inch Z irons, as shown. Each stiffener serves an area of approximately 5 feet 10 inches by 2 feet 1-4 inch hence the total load it supports is:

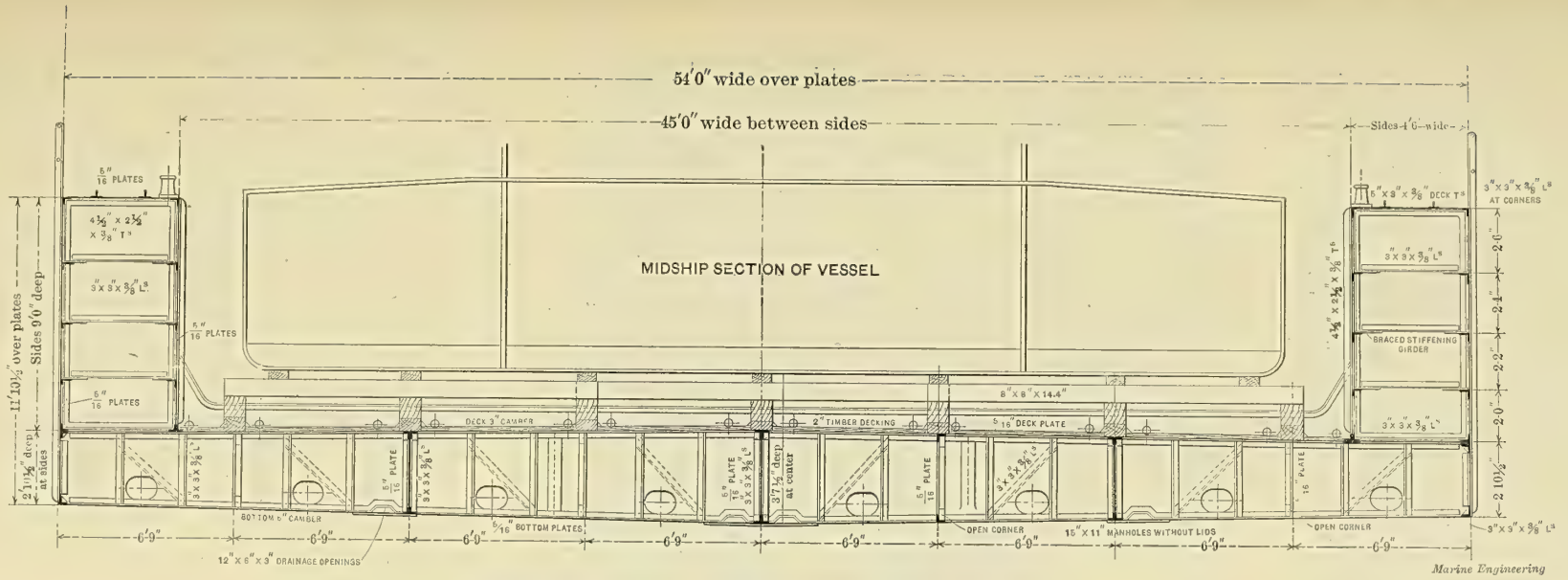
$$\frac{70 \times 24\frac{1}{4} \times 4.45}{2240} = 3.37 \text{ tons.}$$

The maximum bending moment is

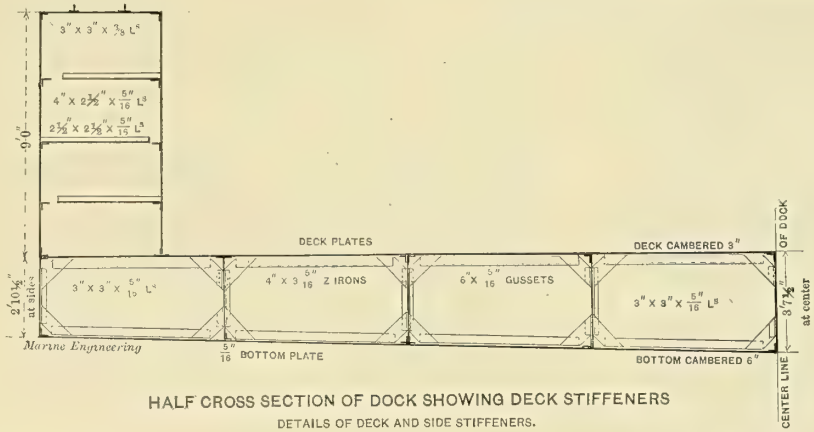
$$\frac{3.37 \times 70}{8} = 29.50 \text{ inch-tons}$$

Assuming that a strip of the bottom plate 10 inches wide acts as a flange to the Z iron, it will be found that the moment of inertia of the small compound girder is 14.37 inch-units, and the maximum stress on the Z bar equals 6.4 tons per square inch.

To stiffen the sides of the dock against buckling, due to the shearing force, and against the water pressure when submerged, three horizontal braced stiffening girders are arranged. The side plating is thus divided into four bays. When the dock is passing under a vessel, the head of water above the center of the lowest bay is 5 feet 6 inches, giving a pressure of 2.4 pounds per square inch on the plating. Considering a vertical strip of the plating in the lowest bay as a

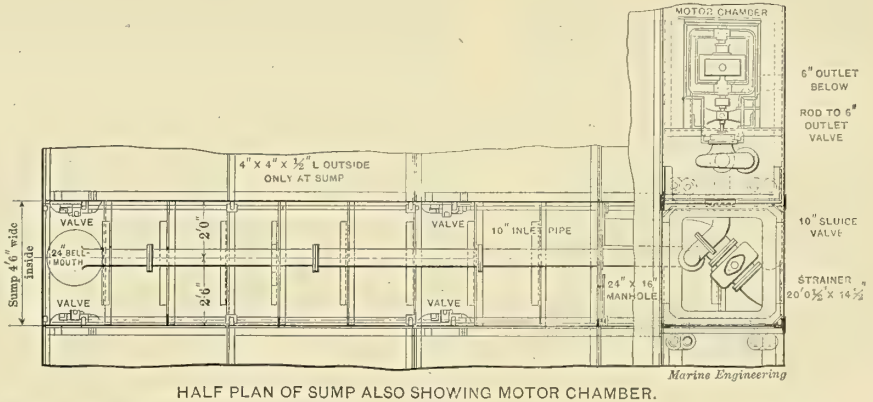


CROSS SECTION OF DOCK SHOWING CROSS GIRDER.



HALF CROSS SECTION OF DOCK SHOWING DECK STIFFENERS

DETAILS OF DECK AND SIDE STIFFENERS.



HALF PLAN OF SUMP ALSO SHOWING MOTOR CHAMBER.

SECTION AND PLAN VIEWS OF FLOATING DOCK FOR KHARTOUM.

bearer 24 inches span, fixed at the ends and uniformly loaded with 2.4 pounds per quare inch, the maximum stress due to bending is 30.5 tons per square inch.

The maximum shear on each side pontoon, as previously mentioned, is 30.5 tons. The maximum stress calculated by Gordon's formula on a column 24 feet 2 inches long, due to a shearing force of 30.5 tons per side, is 2.2 tons per square inch. The above stresses, however, do not occur together. The main 4 inch by 2 1-2 inch by 5-16 inch angles of the horizontal stiffening girders have an unsupported span of

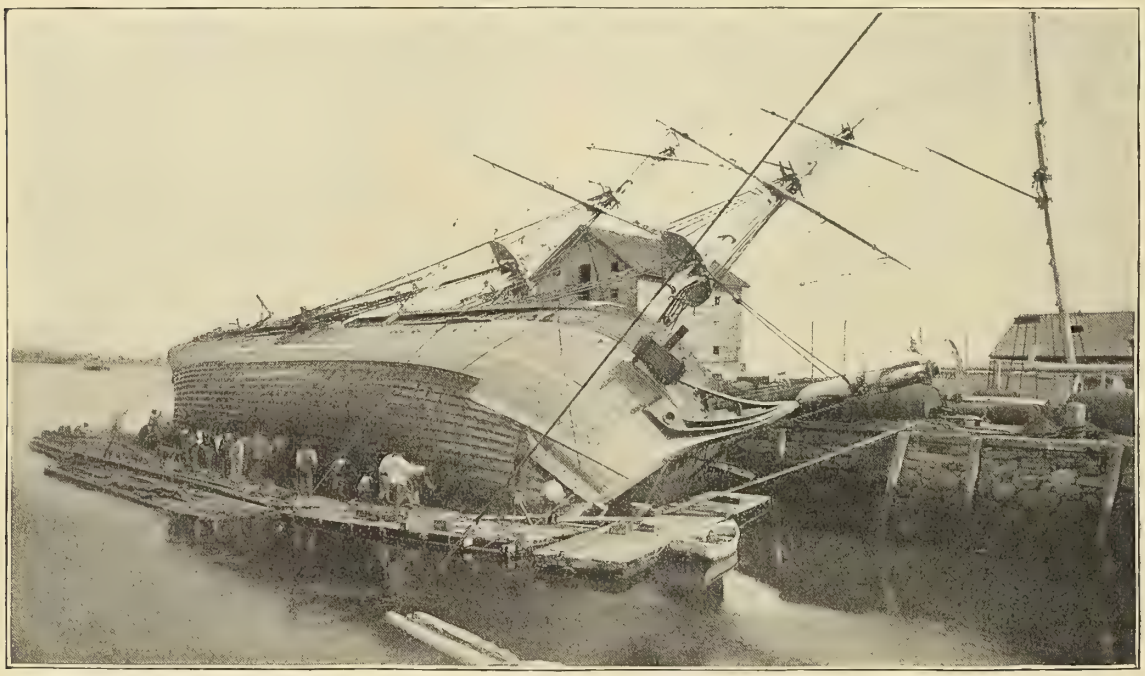
6 feet and 3-4 inch. Taking a span as a beam fixed at the ends, it is found that the water pressure supported by it is 1.59 ton, producing a bending moment of 9.6 inch tons. Assuming that a strip of the plating 9 inches wide acts as a flange to the angle iron, the maximum stress works out to 6.1 tons per square inch.

The deck plating is generally 4 feet 3 1-2 inches wide by 5-16 inch thick, and in lengths of from 15 feet to 19 feet.

In each of the dock sides, near the center, a water tight chamber is formed to contain the motor and pump. The sump is closed at each end by a water tight diaphragm. The diaphragm at one end has a hole 10 inches diameter for water inlet, connection to the side of the dock being made by the 10-inch pipe, sluice valve and strainer. Each compartment is filled or emptied from the sump by a flap valve of 30 square inches area. A deadweight on the lever holds the valve shut, a pin being provided to hold it wide open. The cross girders in each compartment have suitable apertures and manholes, and the stiffeners on the dock bottom are stopped off so that the water may drain away freely. The suction pipe to each pump is 6 inches diameter throughout, and a water tight joint is made where it passes the sump diaphragm and the plating of the motor chamber. The delivery pipe is also 6 inches diameter, and also passes the motor chamber plating by a water tight joint. A 6-inch sluice valve is provided to shut off the discharge when the pump is not in use. A 2-inch air pipe with stop valve is provided, to allow the air to escape from the sump when it is being flooded from outside.

The water tight compartments have each a 3-inch air pipe arranged at the ends of the dock and carried well above the highest water level. They communicate with the top of the pontoons, which may thus be completely filled.

A house is provided on the top of one side of the dock, to contain the valve operating levers, hand wheels for sluice valves, switchboard, etc. Eight cast iron bollards are fixed to the top of the dock sides in convenient positions. A foot bridge is provided at one end of the dock. When not in use each half of the bridge is folded against and secured to the side of the dock. The deck is covered with teak decking 2 inches thick, laid transversely, and secured in position by 2-inch square retaining strips spiked to the flooring, and to the longitudinal teak bearers previously mentioned.



SHEATHING AND COPPERING A WHALESHIP AT NEW BEDFORD.

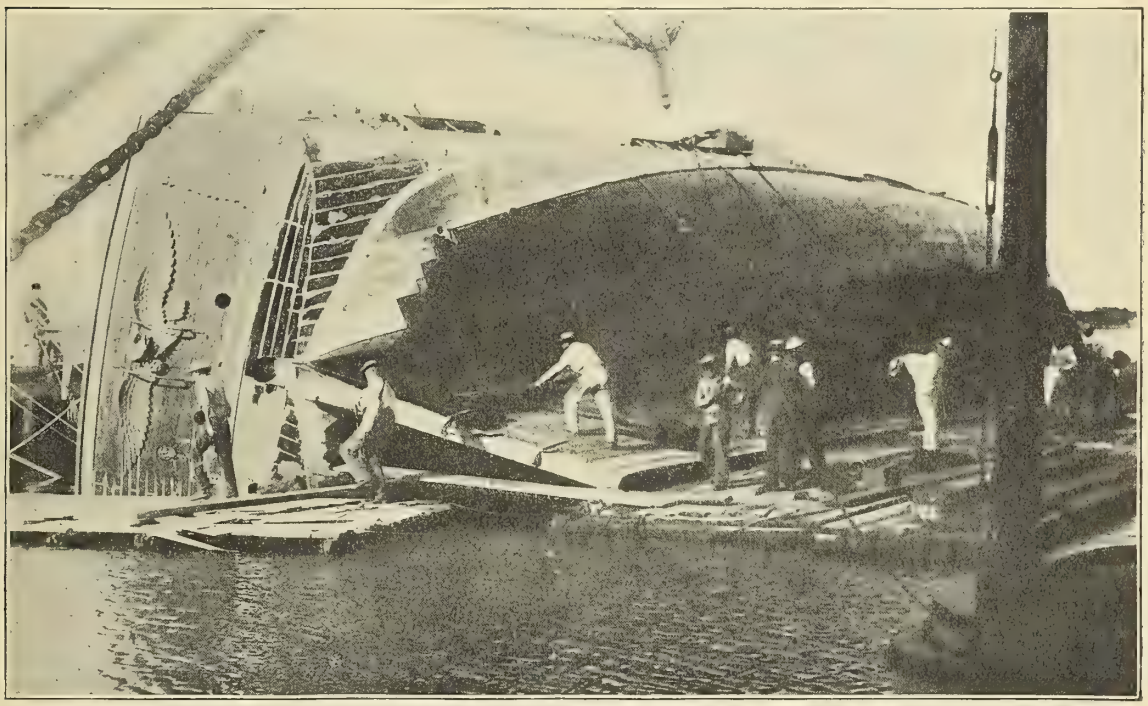
How Whaleships Were Sheathed and Coppered.

The great increase in recent years in the size of vessels has naturally called for a corresponding increase in the sizes and capacities of marine railways and of dry docks, both graving and floating. In this connection it is very interesting to recall the manner in which vessels were frequently repaired.

Among the most staunch vessels that have ever been built for the American merchant marine were the whale ships which sailed from New Bedford and other New England ports. These ships were usually built of live oak, and very staunch, so that they could withstand the punching and the squeezing of ice floes in the Arctic ocean. Before a vessel sailed it was the custom to put her in as thorough condition as possible for a voyage of from three to five years, and, instead of hauling her out on a marine railway, the vessel was usually sheathed and coppered as shown in the accompanying illustration.

A tackle was hooked on to the mainmast and the

vessel was hove down as depicted. Even if more or less water were to get into the cabins and between decks it was easily pumped out. It was not difficult at all to copper the keel on one side, the men working from floats, and the whole side of the ship would be sheathed and coppered while the ship was hove down in the manner shown. She would then be hauled out into the stream, turned round, and the other side sheathed and coppered in the same way. The great strength of these old ships is well demonstrated by the ease with which they withstood the strain of this operation. The accompanying illustration shows a whale ship being repaired alongside the wharf in New Bedford some fifteen years ago.



COPPERING THE BARK SUNBEAM.

Only recently the bark *Sunbeam* was coppered in this same manner. The accompanying picture taken of this bark shows that the hull is first thoroughly caulked and is painted before being coppered. This picture shows the use of floats from which the carpenters and other workmen carry on operations. It also gives an idea of the peculiar shape of the hull of these old whale ships, which are very round and large at the bilge, and which have square sterns, oftentimes with elaborate stern pieces, as this one has. The bark *Sunbeam* is now on a whaling voyage, and was recently reported with a very large catch of sperm oil.

Advertising Classification. — In order that our advertising pages may be more convenient for reference we shall hereafter classify the advertisements more thoroughly. At the top of each advertising page will be found a classification heading indicating the kind of advertisements on that page.

PROPELLER SHAFTS AND NEW FORM OF STERN TUBE.

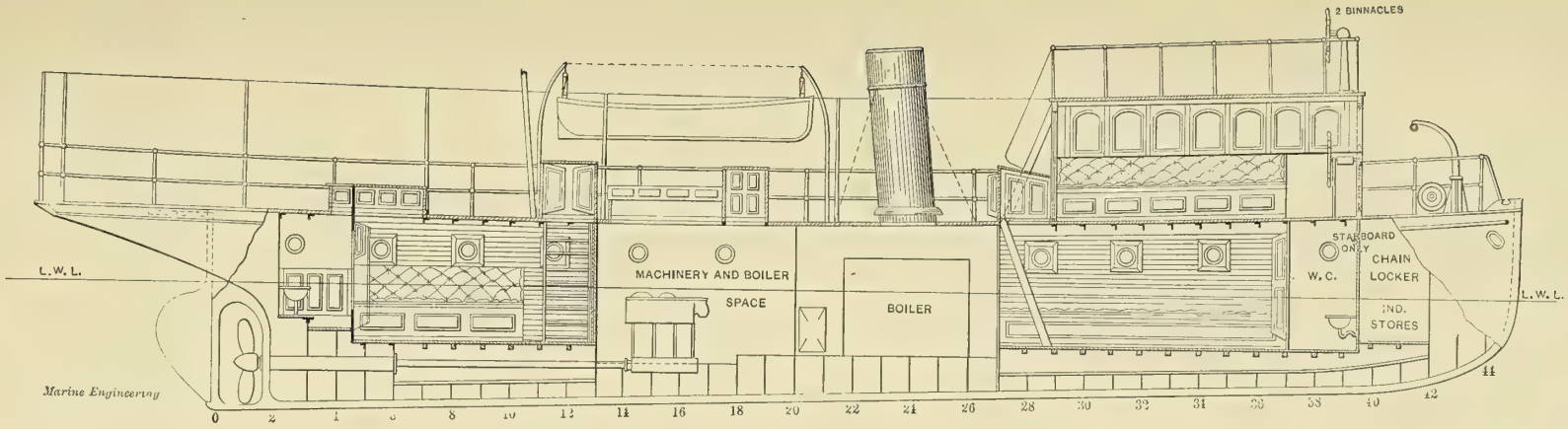
At a recent meeting of the Institute of Marine Engineers Mr. John Corry delivered his presidential address in which he discussed very completely the subject of tail shafts and stern tube bearings. After describing the plans which he had adopted for overcoming certain troubles experienced with the usual flat bottom condensers, Mr. Corry dealt at some length with the subjects of boilers, liquid fuel and turbine propulsion. We make the following extract from his address:—

I have left one of the most important details to the last. It is one that has been very much discussed of late and on which a great deal can be said. I mean the construction and fitting of the tail-end shaft. As a rule the tail-end shaft is fitted into a long cast-iron stern tube. The end next the propeller is fitted with a brass or gun-metal sleeve to work in the lignum vitae bearing, and a shorter sleeve at a distance of several feet is shrunk on, which works in the inner stuffing box. This leaves several feet of bare shaft between the sleeves running in salt water, and exposed to corrosion and galvanic action from the ends of the liners. This I do not consider is a very satisfactory arrangement. But as the bulk of existing steamers are fitted in this manner it may be worth while considering what is the simplest and best method of adding to the life of the shaft without altering the whole construction. The grooving and nicking that goes on at the end of the liners is the principal cause of the shafts breaking and being condemned. The grooving is a combination of three causes—corrosion, galvanic action and the bending of the shaft. There has been a considerable amount of discussion as to the proportion

in which these causes acted, but that they all do act is, I think, undoubted. The bending is, of course, caused by the shaft getting out of line, and working eccentric by the wearing down of the lignum vitae bearing. This would be bad enough in a shaft running on shore, but it is ten times worse in a ship plunging about in a sea-way. Why the shaft bends at the ends of the liners, and not as a whole, is caused by the local weakness at these parts, the sleeves acting as stiffeners, and as the sleeves have seldom been tapered sufficiently off at the ends, the action is strongly localized. The obvious remedy is to cover the whole of the shaft with a long sleeve of gun metal, so as to protect the whole of the surface and to maintain its strength unbroken. This sounds fairly simple, but to carry it out practically is very difficult, especially on the smaller shafts. I believe, however, that there would be no real difficulty if the operation was carried out in a dry well or pit.

The shaft should be slightly stepped, and, of course, the liner, so that that lowest section would slip over the shaft. The heating and all the operations should be carried out vertically; the heating by jets of gas, and the cooling by jets of water. If any large shaft maker would fit up such an apparatus and supply shafts properly covered he would find that it would pay, although I suppose that the present system of broken shafts pays their makers best. However, to cover the shaft as a whole is an operation very few of our engineers care to tackle, preferring to cover it in two, or even three, lengths and burning the joints together. This also is an operation requiring a great deal of care, and may not be quite a success, although it may appear so at the time. The burned ends may, by-and-by, show a very fine shrinkage line, which is quite sufficient to admit the salt water, and when tested by cutting into shows the shaft with a very fine nick carried well down into it. I had a shaft about two years ago which required to be renewed, and as the stern tube was of the ordinary construction if I wished to protect the whole of the shaft I had either to cover it in three pieces and burn the joints together or to cover it with three distinct liners. I preferred the latter, and tapered the ends off with a long taper, and grooved the tapers with a series of rather deep grooves. I then lapped the tapered ends very carefully with thin rubber tape and solution and a series of whipcord roundings. Although the exposed parts of the shaft did not exceed 1-4 inch when we opened out a few weeks ago we found it in perfect condition, and though the bearing was not down more than 1-8 inch I had it relined with lignum vitae. I think if Lloyd's would make a rule that at every two years, when the shaft is withdrawn for examination, the lining should also be renewed, they would be conferring a real benefit on the shipowners. As an alternative, when the whole of the shaft was efficiently protected from corrosive action to the satisfaction of the surveyor, a triennial inspection by drawing in the shaft might be deemed sufficient, if the bearing was at the same time renewed. I believe such a rule would meet the approval of the Committee of Lloyd's Register. The shaft should in the first place be of ample size for its work. I consider that Lloyd's old rules, though much heavier than the Board of Trade rules, erred on the side of allowing smaller shafts to be fitted than is now felt to be prudent, considering the wear and tear and rough handling which steamers in ballast are exposed to. But all this has been very carefully gone into, and the present amended rules now require much heavier shafting. If shafts are built to the present Lloyd's requirements, of good material, and fairly used, we will not have so many mishaps to shafts as has been the case of late. The shaft of the *Star of Australia*, although built before the present rules were in force, is fully up to present requirements as to size. Next to size, and even more important, is material. The material we adopted is nickel steel, which is supposed, and I think with justice, to be both stronger and tougher than either wrought iron or ordinary steel. It is at any rate much dearer. I think, however, if a heavy shaft is made of bar iron, scrapped, of a good fibrous and tough quality, soundly put together, it should make a reliable shaft. What is called scrap iron may be, and generally is, a mixture of scrap iron and scrap steel, and for a tail shaft I think this is not good enough.

In the last two steamers we built we introduced a novel arrangement of stern tube and stern shaft. The stern tube of the *Star of Australia* is comparatively short, being about nine feet over all, and is made of gun metal throughout. It is in two separate halves closely bolted together, on a plan first proposed by Mr. Hector M'Coll, but the details of construction and fitting are my own. The advantage of the stern tube being in two longitudinal halves is that by taking off the nut at stern post the tube can be drawn into the bulkhead and opened out without withdrawing the shaft, merely keeping it carefully suspended in the center of the opening. The two halves are exact counterparts, and there is 8 feet of bored out lignum vitae bearing, in two 4 feet lengths. There is also about one foot of packing, and, about 18 inches from the packing, there is a heavy capped white metal bearing on a strong pedestal about two feet long. With the comparatively short stern tube there is no difficulty in fitting the liner in one piece, and therefore there is no risk or trouble from corrosion. The length of bearing is in all about double what could in the ordinary way be fitted, and even if the bearing wears down a little (and you can readily understand that this is a very slow process) by slacking the nut on boss of stern frame the tube can be turned half round, thus renewing half of the bearing. If you could make sure of excluding sand and dirt from the stern tube the wear would be scarcely appreciable; but to make it complete according to my ideas, an arrangement should be fitted to exclude all sand or dirt so that the bearing could be run altogether in oil. I designed a special gland or packing ring, and an oil pump or feeder, to keep the tube full of oil, not trusting to oil being dropped through a pipe from the deck but forcing it up through the stern bearing and up through a pipe above the water line, and allowing it to flow back into a small tank so that it could be used over again after passing through a strainer. I have, however, not yet been able to carry out the whole of my idea, although I had it all drawn out and the pump ready for fitting, as Mr. Macdonald, the chief engineer of the *Star of Australia*, and one in whose judgment I place a great deal of



STEAM YACHT SKIBO FOR CRUISING IN SOUTHERN WATERS.

confidence (although I sometimes take my own) was rather nervous of starting on a voyage of six months with something he had not tried. The details of the stern tube have been carefully thought out, the longitudinal and fore-and-aft ribs giving great stiffness for the amount of material used. Another point which requires attention is making the joint on the bulkhead by an india-rubber ring. The stern tube is coned in to the stern post and provision made for forcing tallow round the coned end of stern tube to facilitate its being readily drawn in for examination. It is quite easy to renew the lignum vitae, as it can be kept ready fitted. I would make a slight improvement in the *Star of Australia's* shaft by hollowing out the liner close up to the propeller boss, which would be equivalent to tapering the liner at the end, while still retaining a suitable form to hold the india-rubber ring next the propeller boss. If the propeller shaft is fitted as I have described, of ample size of the best material with extra bearing surface, and none of the shaft exposed to the action of the salt water, you have done as much as I know how to insure its efficiency and safety.

Shamrock III.— Press dispatches advise that William Fife is to build Sir Thomas Lipton's next challenger.

Steam Yacht Skibo.

There has just been completed at the Crescent Shipyard, Elizabethport, N. J., a steam yacht of unusual design built to meet special requirements of navigation in southern rivers. The yacht is owned by Mrs. Lucy Carnegie and is for use in day excursions on the rivers and bays on the southern coast. The profile and general arrangements are given in the accompanying illustration. The vessel is 82 feet long overall, 72 feet on the water line, 11 feet 6 inches molded beam, 9 feet 6 inches molded depth, draft 7 feet aft, and 5 feet forward. She has a bar keel 5 by 1 inch, a wrought iron stem and stern post 5 by 2 inches. The frames are two by 1 1-2 inches by 2.7 pounds angles. The reverse frames extend only across the top of the floors and are 2 1-4 by 2 1-4 inches in engine and boiler rooms, and 1 1-4 by 1 1-4 inches elsewhere. The floors are 12 inches by 5.73 pounds. The dock stringer is 14 inches by 5.73 pounds.

The design of this yacht is unusual in may respects. The character of the water of the southern rivers is such that it cannot be used for boilers, therefore, a large tank has been fitted under the boiler room floor. Coal bunkers of exceptionally large size for this little boat will store enough coal for a long trip. Forward is a large cabin for the crew, with berths for four men. Aft of the engine room is the ladies' cabin with accommodations for three. An unusually large cabin is located forward comfortably furnished, and at the forward end of this is a steering wheel. With the exception of the low hatches and companion ways the deck is clear from this cabin aft, and an awning will be stretched the entire length. Above the forward cabin is a bridge deck, and the vessel may also be steered by a hand wheel connected to the one in the cabin. Forward is an anchor davit and small capstan. It is the intention of the owner to use the boat for day excursions, therefore no provision for cooking on board has been made.

The vessel will be driven at the maximum speed of about 13 knots by an engine with cylinders 8, 12, and 18 inches in diameter by 9 inch stroke. Steam is supplied by 1 water tube boiler 7 feet long, 5 feet broad, and 5 feet 4 inches high.

The *Skibo* was launched with engines and boilers in place and all joinery work completed, so that a few days later she was able to proceed South under her own steam.

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Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

FROM a mountain top one sees a wide stretch of country, with its characteristics of hill and vale, lake and river, field and forest, all in one sweep of the eye and without noting the minor characteristics of any one feature. It is well at times for the engineer to take a similar view of his field of work, the better to note the general progress as a whole, to compare the condition of one part with that of another, and to thus enable him to use his own efforts in that part where they are most needed or where they will be most effective.

One of the bold features which the marine engineer would see in taking such a survey of his field of work is that involved in the general problem of the economical development of power by the steam boiler and engine. We know that wastes and losses are constantly occurring all the way along from the coal bunker to the piston rod, where the forces exerted by the steam are first manifest. To what extent can these various losses be reduced or eliminated? Or, in other words, to what extent can the margin which now exists between the highest thermodynamic ideal and actual existing practice be wiped out? To what extent can we profitably carry the existing tendencies toward higher and higher steam pressures? To what extent, if any, can we profitably go beyond the present practice with triple and quadruple expansion engines in breaking up the total expansion into a series of stages? Or, in other words, to what extent, if at all, will the quintuple or sextuple expansion engine find a place in recognized practice? Again, to what extent will the use of superheated steam make possible higher economies, and to what extent will its introduction react on the general problem of steam boiler and engine design? Or, in another direction, to what extent will improved practice with auxiliaries and with the intelligent use of feed heaters and other means of preventing the final loss of heat improve the existing economy of the steam plant as a whole?

Again, beyond the steam boiler and engine, are there possibilities deserving careful study in any of the various forms of gas or internal combustion engines? If so, what form will the most efficient equipment take? Again, beyond the gas engine, what of binary vapor engines such as the so-called waste heat engine recently developed by Professor Josse, of Berlin? Are there to be possibilities in the use of electricity from storage batteries deserving of more serious attention than at present? In short, what is to be the future source and method of developing power for ship propulsion? This most fundamental of all problems may well occupy our serious consideration and study.

WE publish on another page the first instalment of a comprehensive digest of the prize paper by Naval Constructor D. W. Taylor on the balancing of marine engines, read before the Society of Naval Architects and Marine Engineers in November last. A portion of the mathematical appendix will be omitted, as well as occasional paragraphs elsewhere, and in some few cases the substance of a paragraph is given in condensed form. The purpose is, however, to publish this admirable paper in a form sufficiently complete to give to our readers the essential features, especially as regards the practical application to the problem of engine balancing. We would therefore commend this paper to the careful study of all who are interested in this subject of so great importance in present-day practice.

THE condition of the ship building industry throughout the year has been worthy of note in several particulars. While the coast yards have been full of work, while all have shared in good measure in the continuance of our general prosperity, and while many important contracts have been made, it is a fact of interest and importance that no contracts have been made during the year for vessels to engage in the foreign trade. Several large ships are, of course, building in the coast yards for the foreign trade, but these were all contracted for previous to 1901. The contracts of the year have been for coastwise service. The reasons for absence of orders for vessels for foreign trade are doubtless complex and difficult to analyze beyond a certain point. The fact that a shipping bill was likely to be presented at this session of Congress and the uncertainty regarding the provisions of such bill, doubtless had much to do with this hesitation on the part of those who may be inclined to invest in our foreign carrying trade. Again, it is a fact that but few have thus far shown any tendency to enter this field of investment, and those few already have several ships building, and for the moment do not desire more. Again, it may be that there is some apprehension that our present era of prosperity is not to be much longer in duration, or at least that we shall soon pass the crest of the wave and enter a period of decline, how sharply pronounced no one can now tell. These and other motives more or less obscure may be invoked to explain this absence of orders for foreign trade, but the point still remains.

Another notable fact is the absence of naval contracts for the year. This, however, has no special significance, as with the building program in hand it was not desirable to add during the year to the work already in hand. The extent of the naval work now in hand may be gathered from the statement that the total number of war ships under construction is fifty-one, their total displacement 264,987 tons, and their total cost $74,731,666.

The season in the Lake yards has been one of still greater activity than on the coast. New orders in large numbers have been booked, and the American Shipbuilding Co., consisting of the consolidation of the leading Lake yards, was months ago forced to decline further orders for delivery in time for the coming season of navigation.

In these latest types of Lake construction one or two interesting facts may be noted. The first is found in the reaction from the large sizes, which a year or two ago represented the forefront of progress. While these ships of 450 feet in length were considered as representing the most efficient size, and there was a feeling that lengths would soon increase to 500 feet and more, we find on the contrary a pronounced falling off to lengths of from 400 to 360 feet. Doubtless one of the considerations which led to this reduction was the fact that no matter what the length, the draft is always limited by the depth of the shallowest channels which the vessel has to traverse, and there is small prospect of any pronounced improvement in the near future over the depths which now prevail. But with a fixed draft the depth is in consequence fixed, or nearly so, and in Lake practice at twenty-eight or thirty feet. Now with a fixed depth a greater and greater difficulty is found with increasing length in making the ship sufficiently strong and stiff. A length of 500 feet with a depth no greater than thirty feet forms an extreme proportion, which calls for very special and careful consideration from the standpoint of strength, even with the somewhat easier conditions commonly met with on the Lakes as compared with the open sea. Giving to this general consideration full weight and having in view the greater handiness and somewhat greater general availability of ships of more moderate size, and we doubtless have in large measure the explanation of the reaction so far as size is concerned.

Another noticeable point is the absence of water tube boilers from the latest outfits. It has been understood that this was not due primarily to any prejudice against this type of boiler or to any failure or general dissatisfaction with those previously installed, but rather to the fact that their cost is somewhat greater than that of shell boilers, and that the builders of water tube boilers have been too busy with naval work to care for mercantile orders at prices which would compete with those of shell boilers.

On the whole the season has been one of pronounced prosperity for the ship builder. If the future contains nothing worse he will have small reason for dissatisfaction. In one chief point the coast builder may feel more lack of satisfaction, and that is with reference to orders for foreign trade, as referred to above. We may hope that the future contains better things in store, at least in this respect.

THE CONTEST FOR THE PRIZES.

The contest closes with this issue and the result will be announced in March.

Further contributions on this subject will be received and all articles published will be paid for at the usual rates.

Repair of a Tug Boat Boiler Furnace.

The boiler is of the return fire tube type with two furnaces. The diameter of the shell is 8 feet 6 inches and that of the furnaces 31 1-2 inches. The furnaces are of the Adamson ring type, as shown in Figs. 1 and 3. The original condition of the furnace is shown by the dotted lines. In the same drawing is also shown the diminution of thickness and the half section of the repair completed. At *c* the plate was broken through. On the other side in *f*, Fig. 2, the plate was not broken but was reduced to a thickness of 1-16 to 1-8 inch. There was leak also at the point *d*, Fig. 3. After examination of the furnace about the damaged locality, and considering that the boiler was already 10 or 11 years old, it was decided to fit a piece over the weakened portion and on the fire side, as it seemed impossible to properly fit it in on the water side. The steps in making this repair were as follows:—

(1) The thickness was first tested with a hammer in order to determine the suitable size of patch.

(2) The size of the piece was approximately drawn and the location of rivets determined. Small holes were then drilled at the center of rivet holes in order to measure the true thickness of the plate. This was found to be 1-4 inch or slightly more. The diameter of the rivets was taken at 11-16 inch and the pitch at 2 inches, while the thickness of the patch was 5-16 inch.

(3) The furnace plate was thoroughly scraped and cleaned.

(4) Patterns were taken along *HI, JK, MNO.*

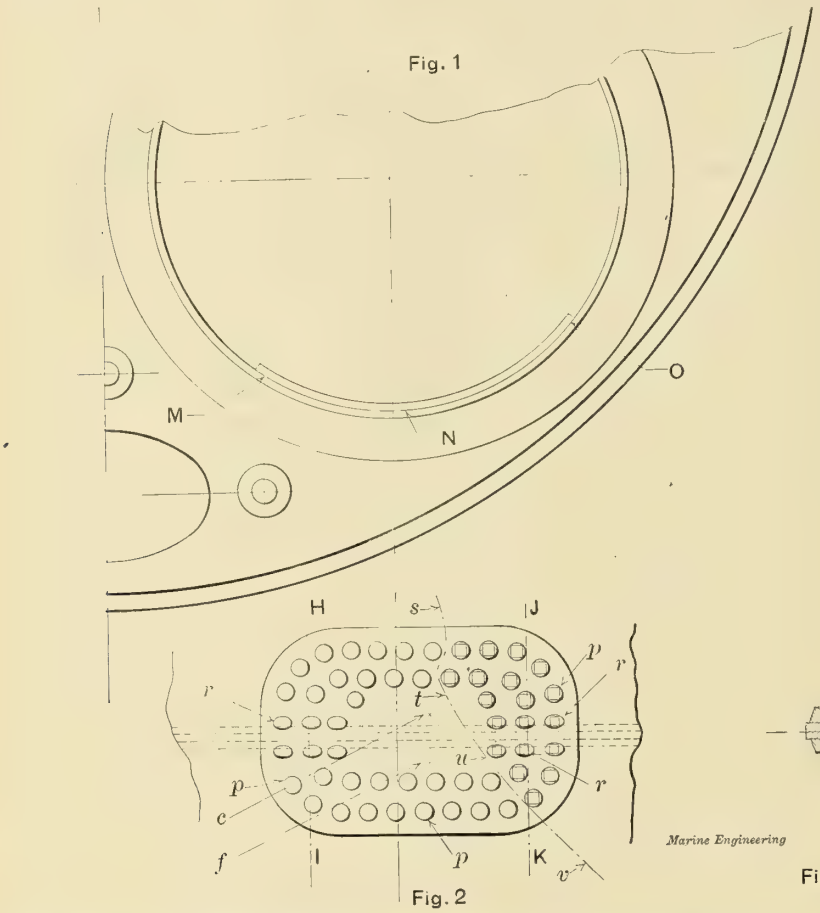
(5) The patch was made according to the patterns as well as possible by fitting and correcting as many times as necessary.

(6) Holes *p* were drilled in the patch and fitted with bolts. The patch was then heated red with a blast lamp and fitted as well as possible, especially at the flange.

(7) The size of the patch and the layout of the rivets were then finally drawn.

(8) Care was taken that the rivets situated near the flange were well drawn in, remembering that the holes were inclined as in Fig. 3.

(9) On the right of the piece the space was too small to allow holding on for riveting so that it was impossible to fit rivets on this side of the patch. After careful examination a line *s, t, u, v,* was drawn limiting the holes where rivets could be driven. The other holes on the right were provided with screws as in *x*, Fig. 3.



(10) Holes on the left were drilled at the correct diameter for the rivets. Holes on the right were drilled at a diameter smaller by 3-32 inch for screws like *x*.

(11) Holes for the screws were tapped through and through.

(12) All the holes on the patch were countersunk. It was found impossible to make the fit very perfect at the flange and in the groove. It was therefore decided to fit putty between the patch and furnace along the groove. This putty was made of sifted iron filings and white lead, mixed with a little sulphur.

(13) The putty was laid on and the patch fitted with temporary bolts.

(14) The screws were put in the holes on the right and tightened well, also the bolts.

(15) The rivets on the left were then driven. It was possible for a man to enter the boiler to hold on.

(16) The rivets, the patch and the heads of the screws were then caulked, holding on where possible on the other side.

This repair was made in March, 1901, and the tug is still in regular use. V.

Repairs Under Adverse Circumstances.

Speaking of mishaps! Well, I have had a few in my time. I will relate my experience in one instance which, though of no great moment so far as expense was concerned, was trying to say the least, and was not without its amusing features.

It happened during the summer of 1880, at the time of the Skagit river gold mining excitement, when all the available small river steamers (stern wheelers) were pressed into service. The river grew smaller, shallower and more rapid as the head of navigation was reached, and at times it was all the three little boats could do to reach their destination. Each tried to outdo the other, thus increasing the excitement of the trip. The result was a couple of safety valves got locked up and two boats dropped out of business. I was engineer of the *Chehalis*, one of the boats that staid on the run as long as there was any business, and the experience I am about to relate happened on one of the trips made during a freshet in the Skagit river. In those days machine shops were few and far between, and much depended upon the skill and ingenuity of the engineer to keep his job in good running order. Just before this particular trip the boat was fitted with larger cylinders, and at the time of which I write I found it necessary to renew the gaskets of all the cylinder heads. The sheet-packing which I procured was, as it proved later, of very poor quality, and the cover bolts were pitched farther apart than they should have been. We had not proceeded very far on our way from Seattle when the cylinder heads began to whistle and I soon had a full-grown edition of a bird store to entertain me. The boat was crowded with gold-seekers, good natured every one of them, and I soon had the engine room filled with an interested audience. Many were the suggestions made, a few of which I heard above the din which was a sort of screeching in various keys. The engine room force consisted of myself and a fireman, and we had our hands full. As the passengers were so ready to help I started some of them in whittling to keep me supplied with pine wedges, for I found that I could not whittle and drive them in fast enough for now and then one would "piff" and fly out skyward, and the noise would reach a crescendo pitch. Before I got through I had the heads bristling with pine sticks, while from behind the bolts, where I could not get at the leak very well, would come unearthly shrieks that were simply hair raising. In despair I covered the cylinders with old sails and tarpaulins in an effort to stifle the noise, and stood by the levers with my hand on the gong lever so that I would know when a signal was made, as it was impossible to hear the ring of the gong. My main object was to keep the boat going, as we had rapids to jump and rocks to dodge. Finally a stop was made to take on wood for fuel. This was a short operation, for passengers and all took off their coats and went at it. The captain came into the engine room and asked me what I was going to do. Pointing to a reel of white rubber hose, I replied that I was going to take enough of it to renew those infernal joints if he would permit it. He gave me permission, and so while others turned to and cut the hose into strips I took off the cylinder covers and in due time had all four joints renewed with rubber hose for packing, and we were again on our way. The boys viewed the proceeding with some misgivings, but I knew that hose would hold as I had used such material for the purpose before. They were soon assured and a shout went up in cheer for the pine wedge engineer.

Things went along swimmingly for a while, and promised to end without further mishap. The little boat was laboring along under all the steam allowed; progress was slow, for the current was strong and the water was shallow. We had proceeded to within a few miles of our destination and the passengers were becoming impatient when the main feed pipe burst with a long split. "I drowned a black cat just before I left." Here was a pretty pickle to be in, and many miles from anywhere! I needed no time to think, for just as soon as the boat was secured to the river bank I proceeded to take down the feed pipe and set the fireman to pulling down the copper jingle bell wire. Any old thing would do to ring that bell with. I cleaned the surface of the pipe, which was a copper one, around the leak and coated it with soft solder, then began wrapping the pipe over the leak with the bell wire, which had been scoured with emery cloth, and soldered it to the pipe with a good hot bitt as I laid the wire on, at the time having someone hold a hot piece of iron against the pipe to keep it hot. When finished the pipe was stronger than when new, and in less than two hours we were proceeding on our way and returned home without further incident. I have always since then kept a roll of about No. 16 tinned copper wire and soldering kit on hand for just such emergencies and have found that it filled the bill several times.

While these incidents amounted to very little in themselves, they show how one may keep his boat going with meager resources at hand.

PINE WEDGE.

Repair of a Boiler Furnace.

This boiler was of the return fire tubular type, half cylindrical vertically with two flat sides. There were two furnaces strengthened with Adamson rings. One of the furnaces was broken through, as shown in *a*, Fig. 1, and *b*, Fig. 2. There was also a diminution of thickness around the hole. After examination of the mishap and considering the space available to receive a man, it was decided to fit a patch on the water side of the furnace. The repair required the following operations.

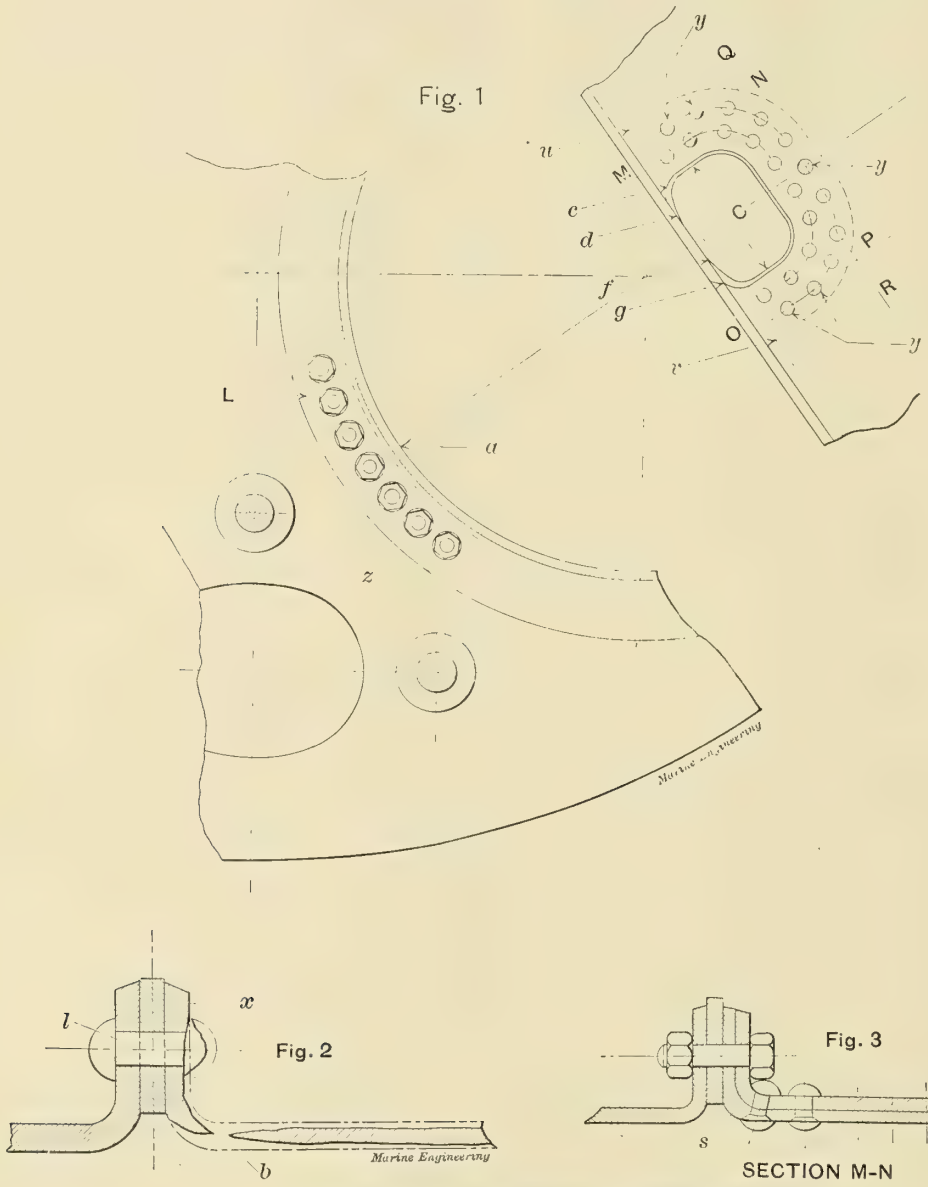
(1) To increase the hole *b* so that the thickness of the furnace in this neighborhood could be measured. This was found to be 3-8 to 7-16 inch. The size of the hole thus enlarged was then laid out on drawing paper, the size of the patch determined and the lay out of rivets. The diameter of the latter was taken at 11-16 inch and the pitch about two inches. At the same time care was necessary that the patch could be introduced into the boiler from the manhole.

(2) The hole was then trimmed to the final size, and the rivets *l*, Fig. 2, were removed from the flange by cutting the heads and drilling out the bodies. Care was taken to cut the flange *x* in *d* and *f* so that the interval *df* should be smaller than the breadth of the hole for 4 or 5 inches. The flange was also made as thin as possible at *c*, *d*, and *f*, *g*. This can be done by working in the furnace.

(3) Take patterns along MN, OP, QR, and *u*, *c*, *d*, *f*, *g*, *v* from which to make the patch.

(4) Make the patch of mild steel of 3-8 inch thickness according to the patterns.

(5) Fit the patch in place and correct it several times if necessary so that it fits very well.



ILLUSTRATING REPAIRS MADE TO A BOILER FURNACE.

(6) Drill in the furnace some holes *y* about 1-16 inch smaller than the true diameter of rivets.

(7) Mark on the patch the holes *l* and *y*.

(8) Shift the marks of the holes *y* out of place 1-16 inch, as indicated in Fig. 4, the holes in the furnace being nearer the flange than the holes in the patch.

(9) Drill the holes of the same diameter as in the flange.

(10) Fit the piece by bolting first with temporary bolts *l* and with two or three bolts *y*. Then tighten them hard. Put a broach in the other holes *y* with a hammer, and in this manner the holes will come fair and a perfect fit will be secured in the angles *s*. Then put bolts in all the holes and tighten them.

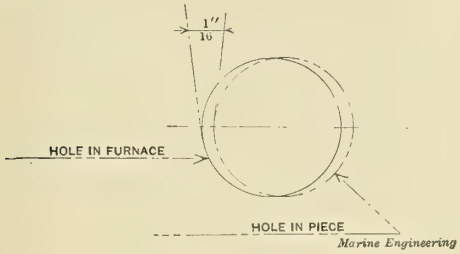


Fig. 4

(11) Drill the holes remaining in the two plates to the true diameter of the rivets.

(12) Heat the patch to redness with a blast lamp and finish the fit with a hammer.

(13) Fit bolts in the holes drilled to the true diameter of the rivets.

(14) Take out the first bolts *y* and bore these holes to the true diameter. Bore also the holes in the flanges *L*, and fit in these holes body bound bolts. Tighten nuts with a box wrench.

(15) Then rivet up the piece. The rivets have flat heads on the inside and are countersunk on the outside.

(16) Caulk carefully the side of the furnace.

In this case the repairs were carried out in the manner above described and the hydraulic test was successfully passed.

QUERIES AND ANSWERS.

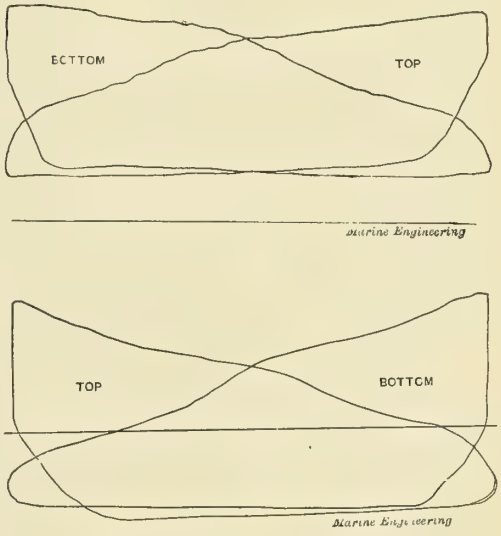
Q. I would like to know if there is any economy in heating feed water with live steam from boilers. The feed water from the air pump is 122°, but by using a heater it is raised to 150°, but to raise it live steam is used. Please let me know if there is any saving in fuel by that process. L. J. P.

A. There is no direct gain in heat by the process which you describe. Many engineers consider that a boiler steams easier and lasts longer when fed with hot rather than cold feed water. Other things being equal, and to this extent there may be some slight advantage gained. In the use of a feed heater the effort should be made to use heat which would not be otherwise utilized, as for example the exhaust of some pump of other auxiliary which is not sent to the condenser. There are feed heaters arranged to be used on the so-called step by step process. In this steam is drawn from the series of receivers of a multiple expansion engine and raises the water successively to a higher temperature. In other words, the steam here used is sent to the heater after having done some work in the engine, but before it has done all that it could. In such cases it can be shown that there is a definite saving. Where, however, the sole source of heat is boiler steam of full pressure, the only advantage will be that possibly resulting from a little easier operation of the boiler, or a little more effective use of the fuel burned in the furnaces.

Q. How many pounds of water at 67° Fahrenheit can be changed to steam at a pressure of 90 pounds per square inch gauge by the burning of 7 pounds of hydrogen, assuming that 23 per cent of the heat of combustion is wasted? J. H. A.

A. (2) The total heat of combustion of one pound of hydrogen is usually taken as 62,000 heat units. If there are seven pounds and if 77 per cent is available this will give for the available heat 7 x .77 x 62,000 = 334,180 heat units. The total heat of steam at a pressure of 90 pounds gauge and above 67°, as taken from the steam tables, is 1,147.8 heat units. Hence the number of pounds of water which can be transformed into steam will be 334,180 ÷ 1,147.8. Dividing this out we find 291. Ans.

Q. Inclosed you will please find a set of cards from a vertical compound (inverted) engine, which I would like to ask you if they could be improved on in any way by valve setting. The high pressure card is a piston valve taking steam on the outside, and the low pressure valve is a slide valve. Please let me know if the engine could be made any more economical, or if you consider the cards good. The size of engine is 44, 75 inches by 51 inches stroke. Steam is throttled at the stop valves on boilers on account of lifting water. G. J.



Pressure at Boilers	92
" " High Pressure Cylinder	78.5
" " Receiver	15.0
" " Low Pressure Receiver	9.5
Revolutions per minute	75
Mean effective pressures:—	
High Pressure Cylinder	39.2
Low Pressure Cylinder	14.25

A. The cards shown are on the whole very good ones. There is some drop in the admission line showing a little wire drawing through the ports, and indicating that a slightly larger port area or opening would be desirable. This is but slight, however, and not more pronounced than is often met with. To judge from the cards the lead is also rather small. Moving the eccentric a few degrees ahead would remedy this but at the same time would give an earlier cut-off with a correspondingly reduced power. The smoothness of running is often dependent on the lead, and it might be that any attempt to increase the lead would result in less satisfactory running than at present. In any event no slight change of this character could have any noticeable effect on the economy. The low pressure cards are also excellent in general appearance, though here also a little increase of lead might be suggested, and perhaps a little later exhaust closure on top. Regarding the distribution of power between the cylinders it is found to be about in the ratio high to low, 1 to 1.06. This shows a very equal distribution, or at least much more so than is commonly met with in engines of this class. The chief limitation to economy in the engine is in the moderate steam pressure employed and in the correspondingly small number of total expansions which the engine is designed for. These, however, are not matters which can be improved by valve setting, and it is probable that so far as indicator cards show, no great improvement in economy is to be expected from any readjustment of the valve gear.

Q. Given an ordinary four-bladed propeller wheel of a certain size and pitch. If it is submerged in a current of water flowing at a known rate, is there any way of finding the power that would be developed? P. P. W.

A. There is no way with our present knowledge of the screw propeller of telling how much power could be developed in such a case. The usual formulae for the design of screw propellers or for the power which they can absorb under the usual conditions do not apply under the circumstances which you describe.

Q. (1) A boiler shell is 63 inches in diameter, and is made of steel plate 3-8 inch thick; what maximum working pressure would you allow? If required to carry a pressure of 135 pounds per square inch, what should be the thickness of the plate? J. H. A.

A. The U. S rule for the pressure allowed on marine boilers is as follows:—

Rule. Multiply one-sixth (1-6) of the lowest tensile strength found stamped on any plate in the cylindrical shell by the thickness—expressed in inches or parts of an inch—of the thinnest plate in the same cylindrical shell, and divide by the radius or half diameter—also expressed in inches—and the quotient will be the pressure allowable per square inch of surface for single riveting, to which add 20 per cent for double riveting, when all the rivet holes in the shell of such boiler have been "fairly drilled" and no part of such hole has been punched.

Following this rule, we have in your case, assuming the steel to have a strength of about 60,000 pounds per square inch:—

$$p = 10{,}000 \times \tfrac{3}{8} \div 31.5$$
or $p = 119$ pounds.

To this we may add 20 per cent, if the joints are double riveted, as they probably would be. This would give 119+23.8= 142.8 or 142 pounds as the nearest whole number below. For a working pressure of 135 pounds the thickness worked out by the same rule would come a little less than 3-8 inch, but so little that 3-8 would be the nearest regular thickness to be employed.

Q. How is the counter electro-motive force of motors ascertained? B. L. D.

A.—The counter e. m. f., or back pressure of a motor, is determined for any given strength of current by passing that current through the armature when it is held stationary, and measuring the voltage by means of a volt meter. This measurement gives the voltage absorbed by the armature resistance for this particular strength of current, and this voltage deducted from the voltage applied to the motor when running with the same current strength, gives the value of the back pressure or c. e. m. f. For example, suppose that we hold the armature of a motor still and pass 100 amperes through it and find that a volt meter connected with the brushes indicates three volts, then if we set the motor in motion with a current having a voltage of 100, as indicated by a voltmeter connected with the brushes, when the current strength is 100 amperes, the counter e. m. f. will be 97 volts; that is, 100 volts less 3 volts absorbed by the armature resistance. As the current passing through the motor armature varies with the load, the voltage absorbed by the armature resistance must vary, and as a natural consequence the counter e. m. f. must also vary, so that the c. e. m. f. can only be given accurately for some particular strength of current.

Q. How can I determine the voltage and strength of current required to charge storage batteries? Does it make any difference whether the current is strong or weak? What time does it require to fully charge a battery? How long will it furnish a current when it is discharged? CHICAGO.

A.—(1) Storage battery cells require about two and four-tenths volts to fully charge them: therefore, assuming that the battery is charged in series, as is usually the case, the voltage required for any battery can be determined by multiplying the number of cells by 2.4. The strength of the charging current will depend upon the size of the cells, and should not be so strong as to charge the battery in less than three hours, and if time is not an object the charging should not be done in less than six or eight hours. The proper strength of current can be obtained from the manufacturers of the cells.

(2) It makes a decided difference whether the current is weak or strong. The stronger the charging or discharging current, the greater the percentage of the energy that is lost in the battery and the more rapidly the latter will deteriorate. Weak currents not only mean higher efficiency, but also longer life for the cells.

(3) The time required to charge a battery depends upon the strength of the charging current, the manufacturers give this information for the different sizes of cells.

(4) The time during which a battery will furnish current on the discharge will depend upon the strength of the current, and as in the case of the charging current the information can be best obtained from the makers as the time does not vary in a proportional ratio with the current strength, but increases faster than the current decreases, and the ratio changes with the different sizes of cells, and also with different makes.

THE PROFESSOR ON SHIPBOARD.

Story of an Attempt to Combine Theory With Practice.

BY C. A. MC ALLISTER, FIRST ASSISTANT ENGINEER, R.C S.

CHAPTER VI.

When the Professor regained consciousness he found himself lying in his berth, with the doctor standing over him. A dim recollection of what had happened gradually dawned on his mind, and in a feeble voice he inquired of the medical officer his opinion as to whether he was going to die or not. To this the physician replied in a very cheerful manner that there was nothing serious the matter with him, and that such accidents were of somewhat frequent occurrence to the men in the engineer's force. Feeling somewhat encouraged, the Professor lapsed into a meditative mood and tried to recollect the circumstances attending his attack. He could remember distinctly that he was standing near the air pump when the thing happened; he had an indistinct memory that the air pump began to roam around the engine room and that the grating flew up and struck him. Beyond that all was a blank, and he shuddered to think of what he had been through. The doctor gave him a little stimulant and he gradually began to take interest in his surroundings. In the afternoon his brother, who had been greatly worried over his brother's prostration, came into the stateroom and spent several hours with him. The chief succeeded in cheering him up considerably, but could not resist the temptation to joke with him good naturedly about his present idea of the theory of heat and thermodynamics.

Under the cooling influence of an electric fan and the gradual administration of nourishment the Professor's condition was so much improved the next day that the doctor allowed him to sit out on deck in a comfortable steamer chair. On the afternoon of the same day Barney, the oiler, who was "off watch" at the time, came up to the convalescent, and, making a bow, said: "Professor, I'm glad that you are able to be around. Shure I thought you was a goner this time." The Professor thanked him very kindly for his friendly expression, and told him to draw up a chair and sit down alongside him. Barney said that he would like to, but he was afraid that some of the deck officers "would chase him off," as he expressed it. The Professor assured him that he would make that matter all right if anybody questioned the propriety of the oiler sitting on deck among the passengers, so Barney got a camp chair and sat down. As the Professor did not feel much like talking, Barney took advantage of the opportunity and spun a number of yarns in regard to the many funny experiences he had encountered in his travels. These put the college man in a good humor as he laughed heartily at a number of the Irishman's witty tales. Finally the conversation turned to the subject of engine room heat and the discomforts encountered in the engine and fire rooms of steamships. Barney assured the Professor that it "was all in getting used to it." To this remark the Professor shook his head and said that he was afraid he would die in the attempt. Barney said: "Oh, never mind, it won't be long before they'll be running

all steamships by electricity, and all the engineer will have to do will be to sit down in an arm chair and open a switch." The Professor replied that he was afraid that that happy state of affairs would not be brought about in their lifetime.

"You see, Barney," he continued, "that the only method by which electricity can be developed on board ship at the present time is by the steam engine. Storage batteries are used to some extent on launches and small yachts, but they can only travel short distances, and must never get a great distance from the power station. So long as electricity has to be generated by a steam engine it will be of no practical utility for ship propulsion. The marine engine of today is, at the best, very inefficient, and it would be still more so if an attempt was made to apply the power to the propellers through the medium of electricity."

The first assistant engineer, who was also off watch, happened along in time to hear this last remark, and as he looked upon Barney as a sort of privileged character, he also drew up a chair and sat down."

"Professor," he said, "what do you mean by saying that the marine engine is very inefficient? From what I have read on the subject I have always understood that a marine engine was about the most efficient type of engine made, and especially when compared with the ordinary type of stationary engine."

The Professor replied: "Yes, that is true, Mr. B——, and perhaps it would have been well for me to have said that any steam engine is very inefficient from a theoretical standpoint. You can readily see that the only way that the efficiency of a steam engine, or in fact any other kind of an engine, can be determined is to compare the actual power developed by the engine and applied to the propulsion of the ship, with the power that should be developed by the consumption of the fuel if none were lost in the process of conversion. It will no doubt surprise you when I state that with the very best types of marine boilers and engines not over 15 or 20 per cent of the power supposed to be developed from the amount of coal used is usefully applied in driving the ship."

To this his listeners both expressed surprise, and Barney remarked that he "knew mighty well that thim firemen didn't half burn the coal in the furnaces."

"Oh! it is not careless firing that accounts for this waste," replied the Professor, "although of course that accounts for a small part of it." The first assistant evidenced a great deal of interest in the Professor's remarks, and asked him if he would not explain wherein there was such a great lack of efficiency. To this the college man readily assented, and after drinking a glass of lemonade which one of the waiters had brought him, he proceeded thus: "You see, scientific men, by a series of experiments in laboratories, have determined that the perfect combustion of one pound of coal would produce on an average about 14,000 British thermal units."

Barney said: "I don't know phwat that is, but why don't they use Irish units?"

This caused the Professor to smile, and he replied that they probably would have called them Irish thermal units if an Irish scientist had determined their value. "However," he said, "a B. T. U. is the amount of heat that is necessary to raise the temperature of one pound of absolutely pure water one degree on the ordinary Fahrenheit thermometer. On board ship it is not possible to burn coal and obtain a perfect combustion such as was done in the laboratories. This is accounted for owing to the impossibility of having furnaces designed to suit the various kinds of coal met with at different ports, and to regulate the admission of a proper amount of air. This imperfect combustion results in the escape of unconsumed hydrocarbon gases, and in the formation of what is known as carbon monoxide, evidenced by a blue flame, which passes off through the stack. Ordinary coal consists of from 75 to 80 per cent of carbon, 2 to 5 per cent of hydrogen, 10 to 15 per cent of oxygen and small percentages of nitrogen, sulphur and ash. The constituent which produces the heat is principally carbon, although hydrogen and sulphur aid a little. This carbonic oxide takes a portion of the carbon away without producing any heat."

"It must be a regular robber," said Barney.

"Yes, you can call it that," said the Professor, and continuing, said: "another great source of waste is that considerable of the heat applied to the water is lost on account of the radiation. Dirty tubes, or tubes partially stopped up by soot are also accountable for more waste of the heat of combustion. The chief loss of the heat is, however, that which goes up the funnel with the waste products of combustion. A certain temperature of these waste gases is, however, necessary for the maintenance of a suitable draft, so that this loss exists of necessity and cannot be reduced below certain limits. As a fair average it can be said that with the ordinary coal used on shipboard, and with a well designed boiler, it is only possible to transmit to the water and steam, under favorable conditions, about 65 to 70 per cent of the heat which would be produced by a perfect combustion of the coal used in the furnaces. The remainder of the heat is absolutely wasted, so that out of every 100 tons of coal bought by the steamship owners at least 30 tons might as well be thrown overboard, so far as any useful work is concerned. Now as to what happens in the boiler. In the first place if you should boil water in an open pot or kettle, that is as we term it, at the pressure of the atmosphere and place a thermometer in it, you would find that the temperature would gradually rise until it reached 212 degrees on the Fahrenheit scale. The mercury would then stop rising for some time, no matter how much fuel you would add or how much you forced the fire. After a while steam would form and escape from the surface of the water. During this time and while the thermometer was constantly showing 212 degrees, heat was constantly being added to the water, and eventually caused it to change from its liquid state into the form of vapor or steam. The heat absorbed by the water during this period is known as the heat of vaporization or latent heat. Although it only takes 180 thermal units to raise the temperature of a pound of water from freezing, or 32 degrees to the boiling point or 212 degrees, it has been found that it takes 966 thermal units to transform the water into steam at the latter temperature. The heat absorbed in bringing the water up to the boiling point

is known as 'sensible heat,' because it is indicated on the thermometer.

"Will that 'later heat' raise a blister on your skin as quick as the sinsible heat?" inquired Barney. The Professor was too much absorbed in his discourse to notice this interruption on the part of the oiler. Continuing, he explained that although water boiled at 212 degrees under atmospheric pressure, if confined in a closed vessel, the boiling point gradually rose with the pressure. At a pressure of 180 pounds in a boiler, the water would not begin to be transformed into steam until the thermometer registered 380 degrees.

When the steam leaves the boilers it, of course, passes to the main engines through the main steam pipe, and even in passing this short distance you may have noticed the pressure is somewhat reduced, owing to the friction in the pipes around the bends and through the stop and throttle valves. This drop in pressure indicates still further loss. When it enters the cylinders there is a certain quantity of it condensed into water, owing to the surfaces of the valve chest, cylinder passages, piston and cylinder heads being at a lower temperature than the steam itself. This loss of heat is attributed to 'cylinder condensation,' and amounts to considerable. Then there are losses of steam through leaky stuffing boxes. The very heat in the engine room which overcame me the other day is a great loss to the efficiency of the engine (not to mention the effect on the men in the engine room), as it is all radiated from the pipes or cylinders. The greatest engine room loss, however, is in the condenser. When the steam leaves the low pressure cylinder its sensible heat has been greatly reduced, so that it is now almost down to the original boiling point. Here, again, we have to contend with the latent heat. In order to transform the exhaust into water again the vapor has to pass through a molecular change. The heat thrown out in this change is transferred to the circulating water, and is passed out into the sea without having done any work."

Barney said: "We ought to set a trap in the outboard delivery valve and catch some of it."

"Well, my man, if you can devise any scheme to utilize a good proportion of this heat, your fortune is made."

"Shure that's aisy," said Barney. "Whin I was on one of the American liners they use to pump up the discharge water for the passengers to bathe in."

"Well," said the Professor, "that no doubt added to the comfort of the passengers, but I don't think it reduced the coal bills to any great extent."

"After all you have said," remarked Mr. B., "it does look as if a steam engine was not very efficient." The Professor then said, "I have only pointed out some of the losses due to the use of the steam. In addition to those we must also take into consideration that there is a considerable loss of power on account of the friction of the working parts of the engine, and in the thrust and stern bearings as well. Then, too, the loss due to the action of the propeller in the water must not be lost sight of."

"Can't some of these losses be reduced?" inquired Mr. B.

"Oh, yes," was the reply; "the estimates I have given you are such that are met with on an average ship, but on very carefully designed and ably managed vessels the efficiency I have named is considerably increased. For instance, in the consumption of fuel, the average ship fitted with a triple-expansion engine uses from 1.8 to 2.0 pounds of coal per indicated horse power per hour, but there are triple expansion engines in use where the consumption of fuel is reduced to as low as 1.5 pound per horse power per hour, and even to about 1 pound in rare cases. This gain in efficiency is accomplished by having well designed engines and boilers, the use of feed water heaters, the heating of the air furnished to the furnaces for combustion, the stoppage of all steam leaks in boilers, pipes, engines and stuffing boxes, etc. Careful firing also adds greatly to the efficiency of a steam plant. Perhaps the most important of these items is the heating of the feed water. It has been estimated, for instance, that on a ship where the feed water is pumped into the boilers at a temperature of, say, 100 degrees, if a heater is fitted which, without entailing any use of heat otherwise useful, raises the temperature of the feed water to 212 degrees, a net saving of nearly 10 per cent in the fuel will be accomplished."

"If that is so, why are not more feed water heaters used?" inquired Mr. B.

"I can only attribute it," was the reply, "to what may be termed 'old fogyism' on the part of old engineers. They go on the principle that feed water heaters were not used on ships when they first went to sea, and they can see no reason why they should use them at the present day."

It was now nearing eight bells, and the first assistant and Barney, who had to go on watch, took leave of the Professor, after thanking him for what he had told them. The Professor spent an hour or so looking out over the blue water and watching the flying fish arising in flocks when chased by some hungry dolphin. Being still somewhat weak and tired, he gradually fell into a doze, to dream of distant places where there are no broken gauge glasses nor hot engine rooms.

Steamer Shawmut. — The Shawmut and her sister ships, described in Marine Engineering of January and building at Sparrow's Point, Md., was also classified under the rules of the American Bureau of Shipping.

Sea Lighters.—The use of lighters in transporting cargo at sea is being introduced by various Continental companies, including England, Russia, Norway, Sweden and Denmark. The North German Lloyd and Hamburg-American lines have each a small fleet of these lighters. The advantages of this means of transportation have long been realized in our own country, and the fleet of lighters plying along the Atlantic coast is annually increasing. At present they are used chiefly in the coal trade, but already companies have been formed to extend this class of service to general merchandise. The number of advantages claimed are the small cost of operating, rapidity of discharging or taking loading (therefore decreasing the time for lying in port), the small capital invested when compared with steamers of the same tonnage, and small expenses of maintenance.

ENGINES FOR DIRECT CONNECTED SETS.—II.

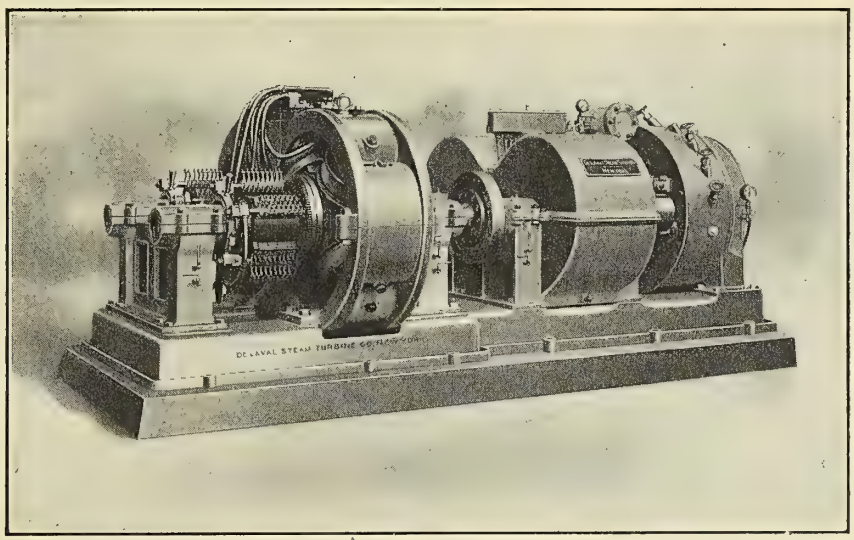
The De Laval Steam Turbine.

In the usual form of steam engine the conversion of heat into mechanical work is effected by using the internal pressure or expansive force of the steam to move a piston to and fro within a closed chamber or cylinder. In the De Laval type of steam turbine the conversion is brought about in quite a different manner. By the use of a divergent nozzle of special form a complete adiabatic expansion of the steam is effected from its original condition down to the lowest pressures practicable, with the complete conversion of the heat energy between these two conditions into kinetic energy of motion in the jet. With the non-condensing turbine the lowest pressure obtainable is of course atmospheric. With the condenser, pressures of 1.47 to 2.94 pounds absolute, corresponding to a vacuum of 27 to 24 inches, may be obtained. This jet of rapidly flying particles of steam is received upon curved vanes and by reaction in the usual manner, the rotation of the turbine is effected.

Velocities of efflux as high as 4,000 feet are by no means uncommon, and by the usual formulae of mechanics it is a simple matter to compute the energy possessed by a jet. Such a jet applied in the most economical manner to the vanes would give about .11 horse power per pound of steam expended per hour, or would show a steam consumption of 9.1 pounds per horse power per hour. This, however, would require an excessively high velocity of the rim of the turbine, a velocity of 47 per cent of that of the steam, or of about 1,850 feet per second. As it has been, however, found difficult to produce a material for the wheels that, with ample margin of safety, would withstand a strain produced by the centrifugal force at this high speed, the actual speed is somewhat lower and does not at the present time much exceed 1,350 feet per second. This indicates a steam consumption of 9.8 pounds of steam per theoretic horse power.

To overcome the impossibility of producing a wheel accurately enough balanced to revolve about its center at such velocities without causing a side pressure destructive to plain bearings and a rigid shaft, a flexible shaft was designed and introduced as an essential feature of the turbine. With the advent of the diverging nozzle and the flexible shaft, the De Laval turbine has steadily progressed, thousands of machines in sizes from 3 horse power to 300 horse power having been built up to the present time, and outside of the United States, De Laval steam turbine companies are operating in Sweden, Germany, France and England.

For the best results the turbine should of course always be operated condensing. Not that the steam turbine cannot, as far as the mechanical results are concerned, be operated equally well with low pressures and non-condensing, and even then successfully compete with the reciprocating engine, but whenever the best economy in operating is sought for, high pressures and a condenser should be used, and as the difference and gain in economy in the case of the steam turbine is more marked than in the reciprocating engine it will be found in many cases, even for comparatively small sizes, of advantage to operate condensing, even in places where the scarcity of water would render the employment of a cooling tower necessary.



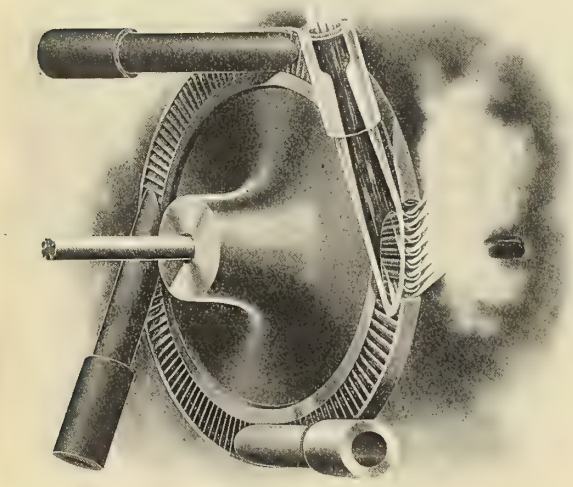
THE DE LAVAL STEAM TURBINE, 300 HORSE POWER.

A characteristic feature of the De Laval steam turbine is that none of its running parts are subject to the full pressure of the steam, as the steam is fully expanded in the nozzles before it reaches the turbine wheel. This feature, which will not be found in any other heat motor, is of great value and promising future in the direction of using high pressures with resultant increase in economy of fuel. The restriction as to the steam pressure that can be used is found only with the boiler, and as far as the steam turbine itself is concerned it has been operated successfully with a pressure as high as 3,000 pounds per square inch.

Further and considerable increase in economy can be attained by using superheated steam, for which the

De Laval steam turbine is particularly well adapted, it having no rubbing parts requiring lubrication, or packing glands in contact with the superheated steam, and, as in the case of high pressures, even here the limit exists alone with the boilers.

The De Laval steam turbine is therefore a high speed rotary steam engine, in design and construction adapted for all purposes where the common reciprocating steam engine is now used. This is especially the case where great efficiency, uniformity of rotation and close regulation are important, as when used in connection with electrical machinery, centrifugal pumps, fans, blowers, etc. Its high speed and the directness of its energy conversion decreases the dimensions and weight, and simplifies the construction without impairing its efficiency, advantages which do



DE LAVAL TURBINE WHEEL AND NOZZLES.

not exist with the modern steam engine where great bulk and complexity are features indispensable to highly efficient operation. Its principal advantages claimed are:

No leakage from wear.
Small friction loss.
High efficiency with variable loads.
No moving parts under pressure.
Simplicity of construction.
Perfect balance—small foundations.
Small space occupied.
Ease of erection.
Automatic oiling.
No danger from water, and long life.

The De Laval steam turbine is particularly well adapted for direct connection to dynamos, centrifugal pumps, blowers, fire engines, etc. All such units are built and tested in the works, which is a decided advantage over the old method of buying an engine from one place, a generator or a pump from another, and having them fitted together on the ground where used, oftentimes with great expense and delay, and probably a poor piece of work as the result. All machines are ready when taken from the car to be set down and operated wherever convenient, nothing being necessary but the connection of steam and exhaust, and switchboard connections in case of dynamos.

Further information regarding these turbines may be obtained from the De Laval Steam Turbine Co., 74 Cortlandt street, New York.

Parsons Steam Turbine.

The Parsons steam turbine is now being built by the Westinghouse Machine Company, of Pittsburg, Pa., and is called the Westinghouse-Parsons steam turbine. The first Parsons turbine with generator was built in 1884, made 18,000 revolutions per minute, and developed 10 horse power. It was used for several years at Gates Head, England, to supply current for incandescent lamps, and is now at the South Kensington Museum.

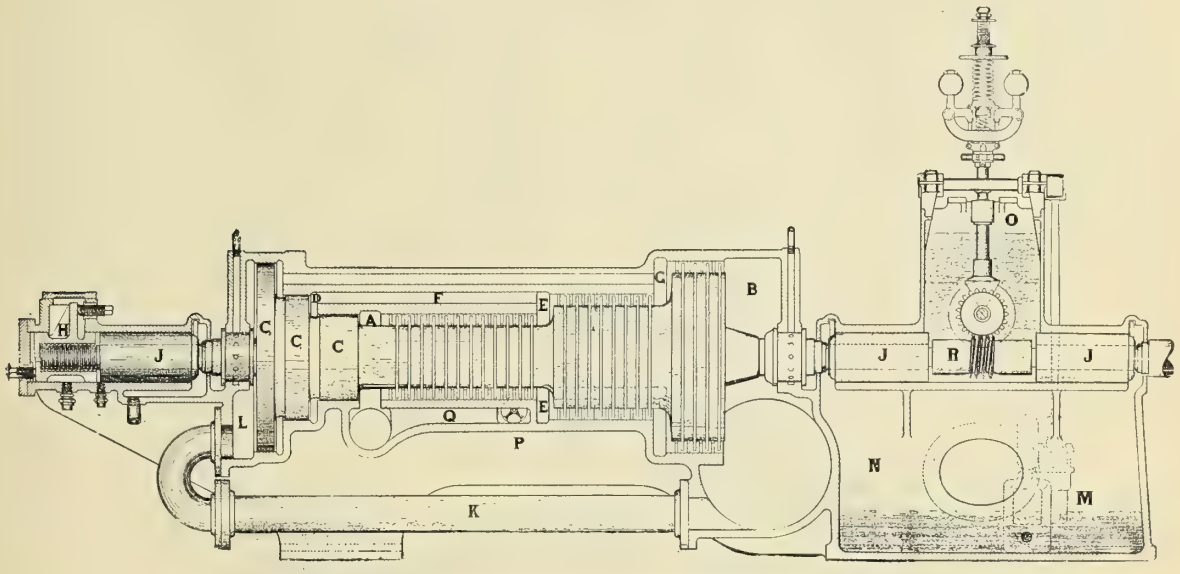
The Parsons turbine was described briefly in Marine Engineering of January, 1902. Herewith is given the longitudinal section for a Westinghouse-Parsons steam turbine. As the action of the two are similar it will not be necessary here to describe those parts previously mentioned. The steam entering the governor valve arrives at the chamber A, and passing through the three successive sets of turbine blades eventually exhausts into chamber B. The areas of the passages increase progressively in volume corresponding with the expansion of the steam. The end thrust is taken up by the balance pistons C, C_1, C_2, which are of the same diameter, respectively, as the three turbines. The pressure in front of each piston is maintained the same as that in the corresponding turbine by means of the connecting steam passages A, F and G—that is, the pressure at D is exactly the same as it is at E. In order that the machine will be more perfectly balanced, the pressure behind piston C_2, in space L, is maintained the same as in the exhaust passage by the connecting pipe K. Thus a correct balance of end thrust is preserved, no matter what the steam pressure may be. However, a thrust bearing H is provided to maintain the correct adjustment of the balance pistons, and is in two halves, the lower half capable of adjustment in one direction, the upper one in the reverse.

The bearings J are unique in construction. The bearing proper is a gun metal sleeve piece, prevented from turning by a loose fitting dowel, and outside this are three concentric tubes having a clearance between them. This clearance fills up with oil and permits a certain amount of the vibration of the inner shell, at the same time restraining it. The shell, however, revolves about its axis of gravity instead of the geometric axis, and the journal is permitted to run slightly eccentric, according as the shells may be out of balance, and thus vibration is prevented. Power is transmitted through the flexible coupling at R, and to this is attached a worm which drives a wheel for operating the oil pumps and the governor gear. The oil drains into the reservoir M, then into the pump N, whence it is raised to the tank O, where it forms a

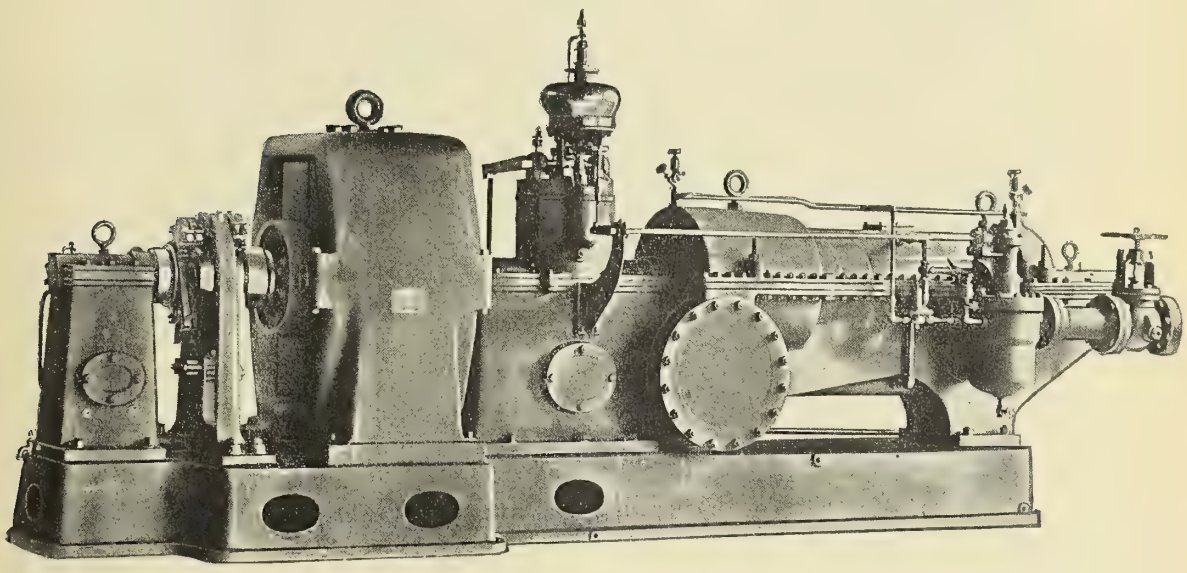
static head, giving a continuous pressure of oil to all the bearings. There is a by-pass at *P* which admits high pressure steam through port *Q* to steam space *E* By opening this valve as much as 60 per cent overload may be obtained.

of the turbine may be varied within all the limits of the governor spring while the turbine is running.

A test of a 300 kilowatt machine, one of the four now in operation at the Westinghouse Air Brake Compan's works, gave the following results:—



LONGITUDINAL SECTION THROUGH WESTINGHOUSE-PARSONS STEAM TURBINE.



500 HORSE POWER WESTINGHOUSE-PARSONS TURBINE DIRECT CONNECTED TO GENERATOR.
TOTAL WEIGHT, 25,000 POUNDS.

A fly-ball governor is made use of, and the ball levers are swung on knife edges in lieu of pins. The governor works both ways, namely, at the mid-position of the levers a full head of steam is admitted to the turbine, and the movement from this in either direction tends to close the throttle—that is, the turbine will be shut down in case of no load, or, for excessive overload, such as a short circuit. The speed

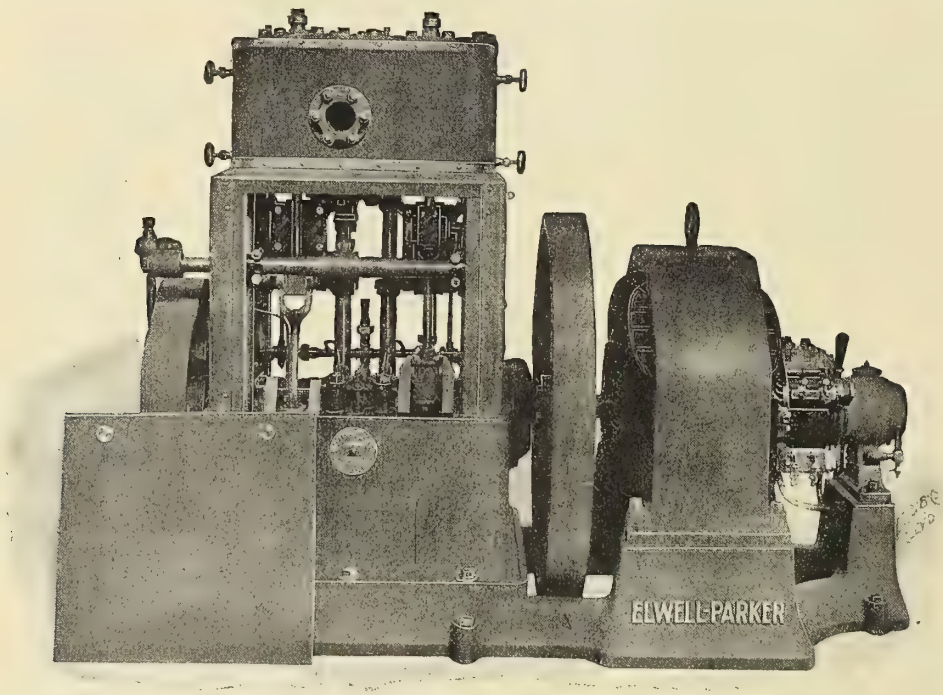
Full load, 16.4 lbs. steam per E. H. P. hour.
3-4 " 17 " " " " "
1-2 " 18.2 " " " " "
1-4 " 22 " " " " "
Running light, 750 lbs. per hour.
Vacuum, 26 inches to 27 inches.
Steam pressure, 125 lbs.
R. P. M. 3,600.

It will be noticed that these latter figures are per electrical horse power, thus giving results for steam in the output of the plant.

Many of these generators are now building, and it is stated that exceptionally good results are being obtained. Among the advantages to be noted are lightness, economy, capacity for overload, absence of fractional surfaces, freedom from vibration, slight cost of repairs, small floor space and automatic action and regulation. These features make the Westinghouse-Parsons turbine eminently suited to marine work.

Forbes High Speed Engine.

The illustration herewith presented is of one of the compound or double cylinder high speed engines, direct connected to a generator, and manufactured by W. D. Forbes and Company, of Hoboken, N. J. Like all engines of this class, the selection of material for the various parts is all important, and, in fact, where high revolutions are made, the workmanship must of necessity be unusually good, but one of the most important, if not the most important point of this class of engine, is to get the reciprocating parts very light and evenly balanced.



TWO CYLINDER HIGH SPEED ENGINE.

The designers of the engine illustrated have followed very closely recognized and well established designs. Search the engine from end to end, and it will be found entirely free from what are usually called "freaks," but the idea has been closely followed that wherever it was possible to remove a bolt or screw or pin from a moving to a stationary part, it was done. This is especially noticeable in the crosshead of the Forbes' engine. Here is simply one piece forged up, making the crosshead and piston rod one, the crosshead shoe being placed on the crosshead guides at the back, and the crosshead brass, a wedge, and one adjusting screw are all the parts that go to make up this important portion of the engine. Again, the connecting rod is forged of especially strong steel, and designed so that the crank brasses are shells which are comparatively inexpensive, readily fitted, and, of course, very much lighter than the usual stub end. As stated, the general make up of the engine is on recognized and approved lines, but the details are carried out in rather unusual ways. The governing of these engines is obtained by the use of the Rites' Governor, which has been adopted by some sixty odd engine builders in the United States alone. The simplicity of the design which W. D. Forbes and Company have gotten up for these governors is such that the entire governing is done by practically two pieces; that is to say, the standing arm and weight, a spring of course having to be used. The wearing parts of the governor are the bushes which fit the suspension pin and the governor pin, and these are of the very simplest construction, and can be made by any machine shop in a comparatively short space of time. Piston valves are used generally on both high and low pressure cylinders, when compounds are made, but the United States navy service demands a slide valve on the low pressure cylinder, and this style is also made. Metallic packing is used on piston rods and valve stems.

One of the most important points of any high speed engine is the oiling system. On double and compound engines the system of forced lubrication is used. This is obtained by means of a single acting pump, and the oil goes to all main bearings, crosshead and crank pin, under a pressure which can be adjusted at will and which has proved highly satisfactory. This system, of course, demands an enclosed case, which rather detracts from the general appearance of an engine, but this is entirely offset by the great advantages gained

by the use of a forced system. On single engines, a sight feed to the various bearings is used and is highly satisfactory, provided reasonable care can be given to the engines. When specially ordered these single cylinder engines are fitted up with forced lubricators.

The weight for the mechanical output on these engines is comparatively small; in fact, it is as light as any commercial engine regularly manufactured, and yet there is no sacrifice in strength. This has been accomplished through a judicious selection of material, together with good workmanship.

Some phenomenal long runs have been reported by these engines, one being over 135 days without stopping. The manufacturers believe that this would not be practical, unless the oiling system was of a forced kind, or unless the engine was lightly loaded; in fact, they lay great stress on this well known idea of ample lubrication.

ENGINEERING SPECIALTIES.

An Intercommunicating Telephone System.

There are two distinct types of interior telephone systems. The first involves the use of a central office, from which a line runs to each instrument. This necessitates of course a switchboard and operator. The second is an "intercommunicating" or "house" system, in which the instrument at each station is placed on a separate line, each line passing through

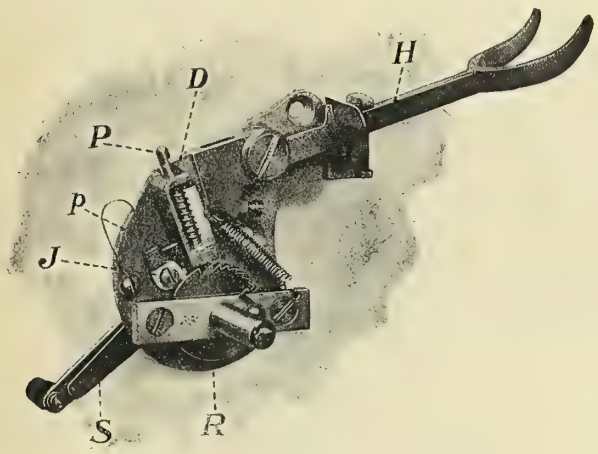


FIG. 1.

all the others instead of through a centrally located switchboard. By means of a simple switching device, the person at any station may connect his instrument with any other station without the intervention of an operator, thus saving the expense of switchboard and other central office equipment, the salary of the operator, and an expert to keep in working order the switchboard and accessory apparatus.

The Ness Automatic Intercommunicating Telephone System, which is manufactured by the Holtzer-Cabot Electric Company, of Boston, Mass., is the best known of the intercommunicating type. The automatic switching device, which is the distinctive feature of this system, is shown in Fig. 1, in which S is the lever of the selective switch, adapted to be rotated over the various contact buttons 1, 2, 3, 4, etc. It is held in any position to which it has been rotated by means of the ratchet wheel R, which is engaged by a pawl P. Upon the short arm of the hook lever, which forms the normal support of the receiver, is pivoted a dog, D, adapted, when the receiver is replaced upon the hook, to engage a notch in the pawl P and lift it out of engagement with the ratchet wheel. This allows a spiral spring to return the switch lever S to its right hand position in contact with the home button. After raising the pawl out of the notch on the ratchet wheel the dog slips out of the notch on the pawl, thus allowing the latter to return into contact with the ratchet wheel in order to be ready for the next use of the telephone. In order, however, that the pawl may not engage the ratchet before the lever S has fully returned to its normal position, a second dog, J, is provided, controlled by a spring so

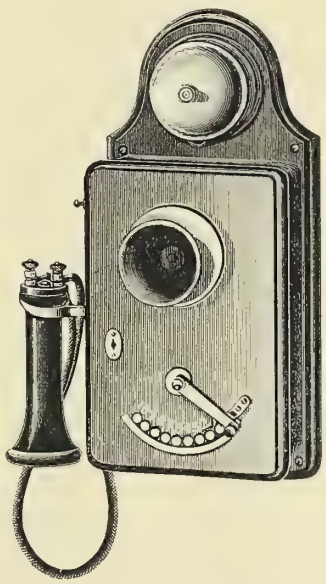


FIG. 2.

as to occupy a position under the pin P, carried on the pawl, thus holding it out of engagement with the ratchet wheel until the rotation of the lever is completed. At this point a cam, on the under side of the ratchet wheel, pushes the dog J out of engagement with the pin P, and thus allows the pawl to drop into position against the ratchet wheel.

This instrument is used in the following manner: rotate the switch arm shown in Fig. 2 until it rests upon the contact whose number corresponds to the station desired, when a slight pressure upon the handle signals the station required without interfering with any of the others. After having finished a conversation, the act of hanging up the receiver automatically restores the switch arm to its normal position, thus preventing an absent minded user from throwing the system into confusion by forgetting to return the switch arm to its home point. This overcomes one of the greatest objections to systems of this kind. Fig. 2 shows a 10 point Ness automatic switch telephone equipped with a standard bipolar receiver and gran-

ular carbon transmitter. This is known as the wall type and may be arranged for use with battery or magnetic call and with centralized or local talking battery, a backboard and battery box being fitted to the 'phone when the latter method is used. The bell, or buzzer, whichever the case may be, may be located either in or outside of the box. Another form of desk set is also made.

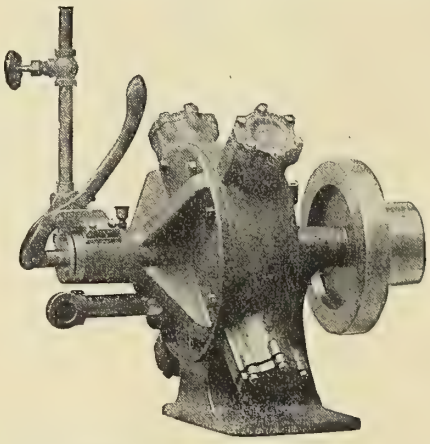
There are many instances in which it is not necessary for the different stations to signal each other, but simply to converse with the central point. In cases like these it is only necessary to have one automatic instrument, the others being single point telephones. Such an instrument as this has been designed especially for use in hotels, large passenger boats or between the various portions of an estate. These instruments are made as carefully as if they were to serve on long distance lines, all parts that are subject to wear being of hardened Stubb steel. The woodwork is of quarter-sawed oak, the trimmings nickel plated, making an ornamental instrument. The more important advantages of the Ness Intercommunicating System are the following: All departments have means of immediate communication with the head office, with the stock room, shipping department and with each other; it is not necessary for the foreman to leave his room or even his desk, and the general manager can easily inform himself of the affairs in all parts of the establishment with small expenditure of time and energy; several conversations may take place at the same time, thus in a 10 point installation five conversations may take place at once without interrupting one another. In short, whatever frequent and immediate communication is desired between any number of points here will be found the sphere of the Ness System of Interior Telephones.

Four Cylinder Engine.

The illustration shown represents an improved steam or compressed air engine designed to meet certain requirements where high speed and light powers are an advantage, such as detached machinery, pumps, dynamos, fans, farm and dairy machinery, etc. It is also particularly adapted to launches and small vessels of every description and locomobiles, owing to its compactness and strength in design of frame, and to the fact that no working parts are exposed to gather dust and dirt.

The most important feature of this engine is its simplicity, which will be apparent to all users of engines, as there are very few parts, all of which are easy of access. There are only two places that require packing. Fig. 1 shows the complete engine as used for stationary purposes. It will be seen that the frame, cylinders and bearings are all cast in one piece. There are four cylinders, single acting, set at right angles to the crank shaft, which is made of one solid piece of steel. The general operation will be sufficiently apparent from the figure.

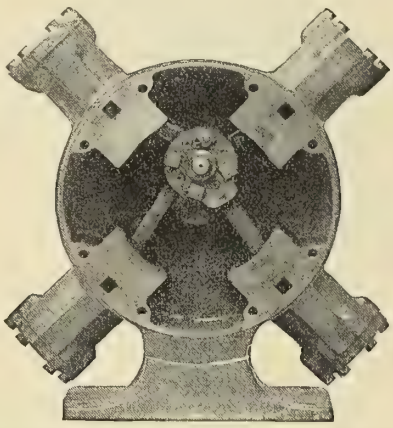
The valve gear is of the rotary type and very simple. It is operated by a disk and is controlled by a lever having a ratchet stop. By this arrangement the motion of the crank shaft can be reversed from right to left, speed slowed down or stopped. By this movement also a variable cut off is obtained, which is, of course, a great advantage for use on launches and locomobiles. In this manner the engine is always under the complete control of the operator. The operation is as follows: Steam is admitted to the side of valve frame, passing through ports in valve to the



LEONARD FOUR CYLINDER ENGINE.

tops of the cylinder and is exhausted back through the same valve to an exhaust chamber in the valve casing, and thence to the exhaust pipe.

All wearing parts are bronze bushed, and can easily be replaced. No attention is required to run the engine other than to keep the oil cups filled. There are no rods to key up or knocking of moving parts inside the casing, as in most engines of this class; and a most interesting feature is that it starts at once and at any point, either right or left, at the will of the operator. It is compact, strong and light of weight compared with the small upright engines on the market.



LEONARD ENGINE WITH VALVE CASING REMOVED.

The sole agent for this Leonard High Speed Engine is Joseph E. Wise, whose address is, Machinery Department, The Bourse, Philadelphia, Pa.

Sinking of the Walla Walla.

No case of collision at sea, involving the loss of one of the colliding vessels and the lives of 39 members of her crew and occupants of cabin and steerage, has created as much interest among seafaring men as that which caused the sinking on the Pacific Coast Steamship Company's steamer *Walla Walla* by the French bark *Max*. The sad accident occurred off the California coast on the morning of January 2d at about 4.35 o'clock, when the ships were five miles north and eleven miles west of Cape Mendocino light. The investigation into the cause of the disaster will determine whether either of the colliding vessels was observing the rules of the road at sea. The declarations by both the captain of the *Walla Walla* and the captain of the French bark, in each of which charges are made against the other of criminal neglect in handling the respective vessels, have drawn keen public attention to the pending verdict of the United States inspectors of hulls and boilers.

BARK MARX AFTER COLLIDING WITH AND SINKING THE WALLA WALLA.

The steamship *Walla Walla*, commanded by Captain A. L. Hall, left San Francisco for Puget Sound ports on the afternoon of January 1st. She carried 64 passengers and a crew of 80 men and officers. The bark *Max* was commanded by Captain Robert Benoist and 29 sub-officers and men. At the time of the collision she was 117 days out from Havre, France, her home port, in ballast for San Francisco, and her skipper was congratulating himself on the splendid time his ship had made around the Horn to the coast. The vessel was on the port tack and standing in toward the Mendocino light, which was plainly visible 11 miles away, when the crash came. The prow of the sailing vessel struck the port side of the steamer abreast of the pilot house. The bark was making two knots speed at the time of the collision and the steamer about nine knots. The force of the impact was increased rather than diminished by the *Walla Walla* sheering somewhat to port at the moment of coming together, with the apparent intention of swinging astern of the bark.

Many different statements have been offered regarding the length of time the *Walla Walla* remained afloat after the collision. Captain Hall stated in the report to his company that the vessel was above water 35 minutes. His estimate is offset by those of half a dozen members of the crew, including the first and second officers, who say that the steamer did not sink for 1 hour and 10 minutes. Quite a number of the rescued passengers concur in this estimate and it has been generally accepted.

After the collision occurred the *Max* drifted slowly away from the *Walla Walla*, but could not be brought about, as her captain feared that he was hurt hard and that the close proximity of a rocky beach would prevent his working his ship in her disabled condition. No boats were lowered from the sailing vessel, but she burned signal lights for some time after the accident, and her commander claims that he returned to the spot where the collision took place just as soon as he was able to work his ship. By that time the steamer had gone down and her boats and rafts with survivors had drifted miles to the northward. From the *Walla Walla* eight boats and four rafts were lowered. Some of these came ashore at Trinidad, on the north coast of California, and while attempting to

land in the surf seven people of one of the craft lost their lives. During the voyage of some of the other boats to different points along the coast, and before the rafts and remainder of the fleet were picked up by the steamers *Despatch* and *Nome City*, a dozen more people perished from exposure, or because of the repeated capsizing of the rafts. The balance of the 43 missing souls that sailed with the ill-fated steamer must have gone down with the ship or have been drowned on jumping overboard from the decks in an endeavor to reach the life-saving craft.

The statement of Captain Hall of the *Walla Walla* contained comparatively little of technical value, inasmuch as he was unable to relate the exact nature of the damage done the steamship beyond the fact that she was struck, as described heretofore, abreast the pilot house. The force of the blow was sufficient to carry the stem of the sailing vessel into the hull of the steamer as far as the center of the captains' cabin. Captain Hall said:

"I had gone to bed at 4.10 A. M., just after rounding the Cape. I changed the course of the ship. I was sitting in my cabin preparing to go to bed when—at about 4.30 o'clock—the whole side of my cabin was suddenly smashed in and something crushed me against my bunk. The pressure was soon released and clearing myself of the wreckage I went on deck and ordered the crew to launch the lifeboats and rafts. The bark was near by, but I did not see any lights. I could not tell the extent of the damage, but knew that we were hit hard, for the water was rushing in the break with a strange sound and the ship took on a considerable list to port and went down by the head. I remained on deck until the ship went down under me, attending to the lowering of the boats and maintaining discipline among the crew and passengers. The downward plunge of the vessel was by the head and to port; she simply slid under at an angle of forty degrees and I was carried with her by the suction.

"While under water I bumped against something, which proved afterwards to be a portion of the pilot house. With desperation I clung to the wreckage and managed on coming to the top to climb upon it. I remained on this raft until 3 o'clock in the afternoon, when the steamer *Despatch* sighted me and I was taken on board and carried to Eureka with other survivors who had been rescued by that vessel."

The first witness called by the United States Inspectors of Hulls and Boilers was Captain Robert Benoist of the *Max*. In a preliminary statement he described the damage done his vessel as a result of the collision, and said that the forward watertight compartment of the vessel had saved her from sinking. The jibboom of the *Max*, which was of steel, was broken and twisted and the tip of it trailed in the water at the port side at about a right angle with the hull. There were four plates punctured and the stem was bent about four feet above the waterline. The hole at the waterline was awash, but the crew of the bark believed the vessel had been struck below the line and did not know just how much buoyancy would be lent by the compartment if the forward part of the craft filled.

Captain Benoist took the stand and made his statement in French to an interpreter. Translated, it read in substance:—

"I am the master of the French bark *Max*. On the morning of January 2d the mate was on watch at 3.45 o'clock. The weather was cloudy, but there was no fog. A rough sea was running and the wind was from the south, veering to southeast, and the course was north 77 east (French computation). The mate came to tell me that he could see the Mendocino light at south 78 east of the compass. The lights of the steamer could be seen at 45 degrees off the starboard bow, but they were clouded at times by her own smoke. The sailor on the lookout reported to the mate and at that moment I came on deck and saw the lights myself and went to the poop and saw the steamer on our starboard side.

"When we struck I ordered a torch to be lighted and the foghorn blown. I could see the steamer fifteen minutes after the collision, and as soon as possible returned to the scene of the wreck and stayed there until noon of the next day. Seeing that our damage was in the forepart of the watertight compartment, I ordered this reinforced and did everything I could to prevent the ship from sinking."

By Inspector Bulger:

"Was anything done on the bark to avoid a collision?"

A. The ship was staying by the wind. After the collision occurred I had her brought about and laid to. We heard no hail from the steamer's crew.

Q. How far apart were the vessels when you first saw the lights?

A. I cannot say, but I think three or four miles.

Q. After the collision did you know that you had cut the steamer down to the water?

A. Yes, sir.

Q. Why didn't you launch a boat?

A. I was too busy with my own ship.

Q. Why didn't you hold to when you found that you had struck the steamer?

A. I did not know that she was so badly damaged. Our forepeak was full of water, but abaft there was very little water. We pumped it out by using the donkey engine. My own ship did not steer well after the collision. I steered toward the Mendocino light with the intention of coming about.

By Captain Hall:—

Q. Did you send anyone aloft at daylight to see if there were persons in the water?

A. Yes, sir.

By Second Officer Lupp, who was permitted to put questions, as he was considered the officer on trial:—

Q. What time did you place your lights?

A. At sunset.

Testimony was given by members of the crew of both the *Walla Walla* and the *Max*, but did not elicit anything conflicting with the testimony of the masters of the respective vessels.

Captain Hall was recalled to the stand on January 10, and in answer to questions by Inspector Bolles testified explicitly to the effect that before going to bed at 4 A. M. he saw no lights except that at Cape Mendocino. Just before turning in he went up on the bridge and noticed that the sky was overcast.

Charles Brown, Third Assistant Engineer of the steamer, was called. He said: "I was asleep at the time of the collision. The jar awoke me and I went on deck. I saw a big hole at the No. 2 hatch and saw a sailing vessel off a short distance. I then went down into the engine room and found no water there. Then going to No. 1 hold I made an investigation to see whether it were possible to shift the cargo from port to starboard to see if the hole in the ship could not be lifted out of the water, but as there seemed to be no hope I returned to the deck and helped get out the boats."

Peter Nelson, first officer of the *Walla Walla*, was sworn and said:—

"I was in bed and asleep at the time of the collision and went on deck as soon as I heard the crash. I saw a big hole in the *Walla Walla's* side and noticed the water rushing into the ship. I ordered the crew to their posts and helped lower the boats. I noticed a flare of light astern. I ordered boat No. 7 to proceed to the light, land the passengers and come back to the ship. We were endeavoring to get out boats Nos. 9 and 10 when the ship went down under us. I went down with her, but came up and was rescued by persons on a liferaft."

Correspondence.

INFORMATION WANTED ON A PRACTICAL POINT.

Editor of MARINE ENGINEERING:

Sir: I should like to inquire through the columns of MARINE ENGINEERING how I could stop the rumbling noise that steam makes when turned into the water heater. I know that there are arrangements which I could buy, but I should like to learn of something that I could make myself on board ship.

Respectfully,

L. J. P.

BOOK REVIEWS.

The Record of American and Foreign Shipping, 1902. Published by the American Bureau of Shipping, 66-70 Beaver street, New York; 1272 pages.

This is the fourtieth annual issue of the registry and classification of ships published by the American Bureau of Shipping, formerly the American Shipmasters' Association of New York. The Record contains full reports and particulars about vessels of all classes and nationalities, also rules for constructing and classifying vessels of steel, iron and wood and rules for constructing and surveying steam machinery and boilers for vessels, regulations for the installment of electric lighting and power apparatus on shipboard and other special information of importance to the shipping world. There are also included, lists of the addresses of prominent shipyards, dry docks, marine railways, engine and boiler builders throughout the United States, a list of vessels whose names have been changed and compound names indexed by the last name, lists of surveyors at the various ports with names and addresses of owners of vessels classified in the Record. One of the special features of this year's edition is that the tables of dimensions for constructing steel vessels have been brought up to include ships of the largest size. The work has been thoroughly revised and brought down to date.

Centrifugal Pumps, Turbines and Water Motors. By Chas. H. Innes, lecturer on engineering, Rutherford College, Newcastle-on-Tyne. Pp. VIII, + 296, with 239 figures in the text. Size 4 1-2 by 7 inches. The Technical Publishing Co., London. Price, 4 shillings 6 pence.

This book aims to place before the student in concise form the theory of turbines, centrifugal pumps and fans. The author develops his theory of the subject as an expression of the three fundamental principles—the law of conservation of energy, the law that the change of angular momentum is proportional to the angular impulse of the force producing it and the law or assumption that the losses of energy in a stream are proportional to the square of the velocity of flow. Based on this exposition of theory, the author then develops methods of design, both analytical and graphical, which should prove of practical service.

In addition to the discussion of theory and design the author gives a considerable amount of descriptive matter relating to the various types of turbine and centrifugal machinery found in practical use. The book contains also a descriptive chapter on the steam turbine, and chapters on the centrifugal and axial flow fans.

The theoretical matter is clearly put and does not attempt to go beyond that which is needed for the purpose which the author has in hand. The methods of design are clearly explained, and are put in such form as to be readily applied to actual problems. The illustrations are frequent and, for the most part, well chosen and executed. As a whole the book is a distinct and valuable addition to the literature of the subject, and should be of value to those interested in the design and operation of machinery of this class.

Power and Power Transmission, by E. W. Kerr, Asst. Professor of Mechanical Engineering, Agricultural and Mechanical College of Texas. Size, 5 1-2 x 9 inches. Pp. 356, with 264 figures in the text. New York, John Wiley & Sons. Price $2.

This book represents the substance of lectures delivered by the author to students of the elementary principles of engineering. Since the activities of the mechanical engineer are chiefly concerned either with the development of power or with its transmission to the point where it is to be used, the subject matter of the book may properly include nearly the whole field of mechanical engineering. Such is indeed the scope of the subject as treated by the author, and we have in this brief compass a discussion of the chief elements of general mechanical engineering in its various branches. The book is divided into three parts, the first covering the general subject of machinery and mechanics, the second that of steam power, and the third that of pumps, gas engines, water power, compressed air and miscellaneous topics. To cover this wide range of topics the author has naturally had to make selections among the vast amount of material available, and to present such parts as seem most important or best suited to the needs of the

student of the subject. On the whole these selections seem to have been made with care and good judgment. No two writers would, of course, agree in the selection of the material under these circumstances, but it can be fairly said that the student who is familiar with the topics here presented will have at least made a good start in the principles of mechanical engineering, will have become acquainted with many of its details, and will be well fited to go on into the specialties of the profession in such branch or branches as he may wish to pursue. The printing, binding and mechanical make-up of the book are in the well known and standard educational style of the publishers.

Marine Almanack, 1902. Edited by Mittheilungen aus dem Gebiete des Seewesens, Gerold & Co., Publishers, Vienna, Austria. Pocket size. Pages 582, with marginal index, blank sheets for notes, and pencil case, and many illustrations. Price, 4 1-2 marks.

This publication, which is yearly prepared under the immediate auspices of the Austrian Department of Marine, again comes to hand with its wealth of information on all points relating to the warships and navies of the world. While it is primarily intended for German speaking peoples, its accuracy, extent and variety of information and convenience in arrangement and size have justly extended its use as a convenient and compact source of information on the subjects of which it treats.

Aside from the calendar and other information of general interest, the subject matter proper is presented under five heads.

Part I. contains a collection of various tables of weights and measures with reduction tables for conversion from English to metric and vice versa. These tables will be of special value to the American or English reader as giving a ready means for converting into English measures the data given elsewhere in the book.

Part II. for the past two years has contained an admirable digest of international law, especially as related to naval warfare. In the present issue the place of this is taken by a digest of the laws and regulations relating to the naval personnel and to the administration of naval affairs generally. This section, while doubtless of interest to the Austrian naval officer or to the student of naval administration, has for the general reader hardly the value of the digest of international law which we have been accustomed to find at this point.

Part III. gives the usual tabular presentation of matter relating to naval ordnance.

Part IV. gives in the usual tabular form the leading characteristics and particulars of the various ships belonging to all naval powers. This covers 164 pages, and seems to have been prepared with the usual accuracy and care. This tabular matter is then followed by 141 pages of line drawings, showing the general appearance of leading and representative ships of the various navies, with diagrammatic representations of the character and distribution of the armor and main battery.

Part V. contains the Austrian Navy list, and has therefore but small interest for the general reader.

This little publication has justly gained an assured place in naval literature, and properly ranks high as an authoritative collection of data relating to the ships and naval ordnance of all naval powers, and may be cordially recommended to those who may wish to have at hand information on these subjects.

The Engineering Index for the years 1896-1900. Edited by Henry Harrison Supplee. Size, 6 by 9 inches. Pp. 1030. Published by the Engineering Magazine, New York. Price, $7.50.

Perhaps the most astonishing feature of the modern development in science and engineering is the prodigious extent of the literature published on the subject and the vast number of things which a man must remember about, or at least be able to promptly locate if he wishes to keep measurably well informed on the details of his profession. To this end the engineering index has become one of the necessities of the library or office shelves of the live engineer.

In 1884 the idea of an index of engineering periodicals was put into practical form by Professor J. B. Johnson, then professor of Civil Engineering at Washington University, St. Louis, Mo. This index was published in the Journal of the Association of Engineering Societies from 1884 to 1895. In the meantime, a somewhat similar movement having been undertaken by the Engineering Magazine, in 1895 the work carried on by Professor Johnson was relinquished in favor of the Engineering Magazine, which has carried it on to the present time. The breadth of the work thus carried on has constantly increased until at the present time it consists of a fully classified monthly index of the contents of nearly 200 technical journals published in the United States and Europe.

The purpose of the present volume is to gather under one cover the monthly indexes which have been published during the past five years, or for 1896-1900 inclusive. There have been two preceding volumes covering the years 1894-1891 and 1892-1895. The scope of the present volume may be inferred from the statement that it comprises some 40,000 entries drawn from about 200 sources, being about four times the number of entries per year found in the earlier volumes.

Each entry gives the title of the article, the author's name, a few lines descriptive of its scope or of the chief points, its approximate length in words, with the name and date of the periodical where published. Much of the value of such an index depends, of course, on the arrangement under classes, headings, catch words, etc. These features seem to have been given careful attention, and the system followed is fully explained in the introduction, so that any given topic may be found with the minimum of time and trouble. The work represented in the preparation of such a volume is, of course, enormous, but it is well that this has not deterred those having the matter in charge from carrying it on, and that, thanks to this combination of business enterprise and engineering skill, we have this valuable collection of references to the engineering literature of recent years. The volume may be most cordially recommended to all who are interested in keeping in touch with engineering progress, as shown by the current periodical literature of the subject.

Water Tube Boilers. By Leslie S. Robertson. Size 5 1-2 x 8 1-2 inches, pages 193, cuts 170. Price $3. New York: D. Van Nostrand and Co.

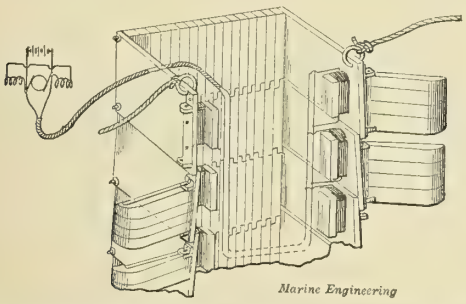
This book is based on a short course of five lectures which the author was invited to deliver at University College, London. There is no attempt in this book to cover the subject of water tube boilers with the same exhaustiveness of treatment as that found in the French work of M. Bertin, and which Mr. Robertson has translated into English. The present work does, however, contain a considerable amount of material which the author has drawn from this source. The main purpose of the author is rather to provide a descriptive book on the subject at moderate price, and to which students and practical engineers might refer. Chapter I. deals with the subject historically. Chapter II. discusses circulation, draft, combustion and a series of other topics relating generally to the operation of this type of boiler. Chapter III. takes up the modern boilers of the large tube type; Chapter IV. those of the small tube type, and Chapter V. the general subject of boiler accessories. In an appendix is given the now somewhat celebrated "interim" report of the Admiralty committee on water tube boilers.

In so far as the purpose of the author was to provide a descriptive and semi-popular work on this subject, he seems to have succeeded admirably. The subject is most fully illustrated and contains cuts of all manner of water tube boilers, those introduced in the early periods of development and only interesting from an historical standpoint, as well as those found more or less commonly in present day practice.

The only question which may arise is perhaps as to the field of usefulness of a book containing so little beyond the purely descriptive. The student and the engineer are often interested in the descriptive, but it may be fairly questioned if the book would not have been enhanced in value by the omission of a part of the purely descriptive matter and the insertion of a somewhat fuller treatment of the subject of circulation and of other points of perhaps a somewhat greater practical present day importance. The book is well printed and bound, the illustrations are for the most part well executed, and the book will have its value for all who are interested in the water tube boiler as the coming steam generator for marine purposes.

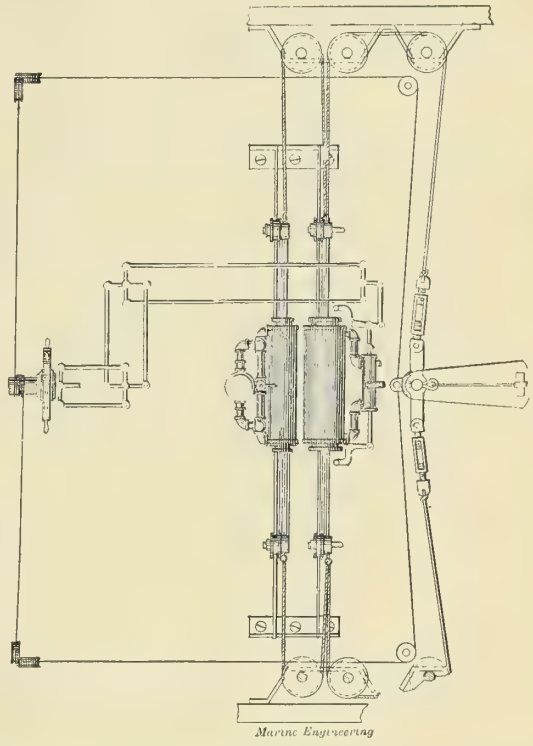
SELECTED MARINE PATENTS.

689,970. CAISSON FOR REPAIRING VESSELS AND SUBMERGED SURFACES. DAVID MASON, NEW YORK, N. Y.



CLAIM.—Means for repairing and inspecting the sides and bottom of a floating vessel consisting of a flexible vertebrated water tight caisson made up of separable sections, the outer surface of which consists of a series of blocks joined together by bolts extending laterally through them, the lateral sides of the caisson being composed of overlapping steel plates secured by the same bolts which hold the separable sections together; in combination with means for causing said flexible caisson to adhere to the side or bottom of the vessel when properly located in position, substantially as described.

689,145. ENGINE FOR STEERING VESSELS. FRANK B. TURNER, VANCOUVER, CANADA.



CLAIM.—In a steam steering gear, the combination with the parallelly disposed steam and oil cylinders, the piston rods which are adapted to connect with the tiller of a ship; of a valve mechanism disposed between and having communication with the opposite ends of the steam cylinder, lever devices connected to the opposite piston ends of the said valve, and devices on the opposite ends of the piston rod of the steam cylinder for engaging the said lever devices, for the purposes described.

689,648. SAIL. GEORGE A. LOWRY, CHICAGO, ILL.

CLAIM.—A sail composed of independent sections, each section separated from but overlapping the next adjacent section, whereby each section spills the wind away from the other or adjacent sections, as and for the purpose set forth.

2. A sail composed of independent sections of increasing width from one end to the other thereof, said sections overlapping each other at their widest ends, but separated from each other.

689,782. VESSEL. WILLIAM BLANCHARD, SCRANTON, MISS.

CLAIM.—In a vessel, a hull having an outer and an inner sheathing spaced from each other, said inner sheathing forming a storage reservoir, a cover for the reservoir, a deck located above the reservoir and spaced therefrom, forming an intermediate chamber, and open-ended tubes extended across the space between the inner and outer sheathings and communicating with the intermediate chamber and the exterior of the vessel.

689,784. STOP MECHANISM FOR ENGINES. WILLIAM F. BRADBURY, KANSAS CITY, KANS., AND DIXON E. WASHINGTON, KANSAS CITY, MO.

689,821. HULL CONSTRUCTION. CHARLES H. HOWLAND-SHERMAN, WASHINGTON, D. C.

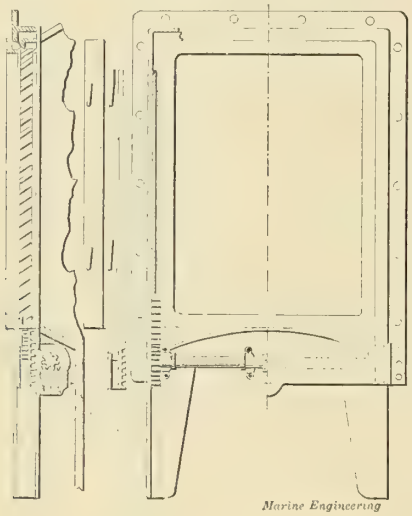
CLAIM.—Combined in a hull structure, a keel proper having a central, superior longitudinal channel and longitudinal enlargements along its sides; and a web-keelson centrally attached thereto; the construction being such that both the said web-keelson and keel enlargements are adapted for attachment to the contiguous parts of the hull structure, substantially as described.

690,029. BOAT WILLIAM B. MOTHERAL, NORTH McGREGOR, IOWA., assignor of two-thirds to Charles Z. Pote, Washington, D. C., and John S. Rodgers, Charleroi, Pa.

CLAIM.—A boat having a bottom with a flat middle portion, and inclined portions on each side thereof of varying pitch, substantially as set forth.

2. A boat having a bottom with a narrow bow, and wide stern, formed with a central flat portion increasing in width from bow toward the stern, and inclined portions of varying pitch on each side of said flat portion also increasing in width from bow toward the stern, substantially as set forth.

690,032. SIDE LIGHT AND WINDOW FOR SHIPS. GAVIN C. RALSTON, LEWISHAM, ENGLAND, assignor to J. Stone and Company, Deptford, England.



CLAIM.—A sliding window sash guiding for reciprocating motions in the fixed frame, the latter provided with a rubber ring for the sash to make joint with, means for reciprocating the sash and for holding it stationary in the closed or partly closed position, and mechanism on the inclined plane principle for moving the sash toward the rubber ring and pressing it against the same, substantially as set forth.

2. A sliding window sash provided with slanting lugs, a tooth rack on each side provided with slanting surfaces between which the aforesaid lugs pass in the closing of the sash, a fixed frame provided with joint seating ring and wherein the sash and the racks are guided and wheel gearing on the fixed framework for moving the racks and the sash together therewith, and for finally pressing the sash horizontally against the joint seating substantially as set forth.

690,089. VESSEL UNLOADING APPARATUS. GEORGE P. WETMORE, SAN FRANCISCO, CAL.

CLAIM.—The combination with a barge or vessel, of a series of compartments, having discharge chutes with controlling gates, an endless traveling carrier located beneath and adapted to receive the discharge from either of the chutes, a framework with endless elevator, a drum and driving shaft about which the lower end of the elevator passes, supports axially in line with the driving shaft upon which the lower ends of the elevator frame are supported, and means for delivering the material from the carrier to the elevator.

690,215. RECREATION SUBMARINE BOAT OR BOAT VEHICLE. JOHN WILSON, PERTH AMBOY, N. J.

690,216. SCOW. CHARLES WINK, POMEROY, OHIO.

CLAIM.—In a scow or other vessel, means for securing the floor timbers to the hull, comprising a plate secured to the hull, a socket in the said plate adapted to receive the floor timbers, a key seat in the socket and a key in said key seat.

2. In a scow or other vessel, means for securing the floor timbers to the hull, comprising a plate secured to the hull, arms extending from said plate adapted to hold the floor timbers, a recess in said arms, and a key adapted to enter said recess.

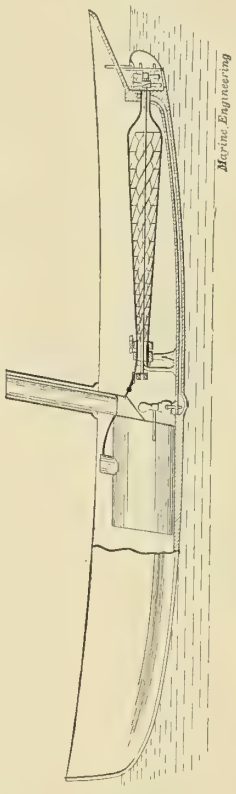
690,267. MEANS FOR PROPELLING VESSELS. ROBERT F. GILLIN, BROOKLYN, N. Y.

CLAIM.—The combination with a vessel of a cylinder of large cross sectional area arranged with its axis in a plane passing through the central longitudinal line of the vessel, having its forward end closed and its rear end open, and extending through the hull below the water line, an open branch pipe of smaller cross cestional area extending from the cylinder on each side near the forward end through the hull below the water line, approximately parallel with and in the same direction as said cylinder, the combined discharge capacities of said branch pipes being co-equal with the discharge capacity of said cylinder, a plunger in said cylinder, and means for reciprocating it therein, all substantially as and for the purpose herein specified.

690,685. LIFE BOAT. ALEPH ANREP, MOSCOW, RUSSIA.

CLAIM.—A life boat adapted to be launched from a vessel, having the lines of the deck and bottom at that end of the boat which is ahead in launching, forming with each other an acute angle, and having the lines of the deck and bottom at the other, or following end of the boat curved upward, whereby the boat is caused to dive through the water in a downwardly curved path, substantially as set forth.

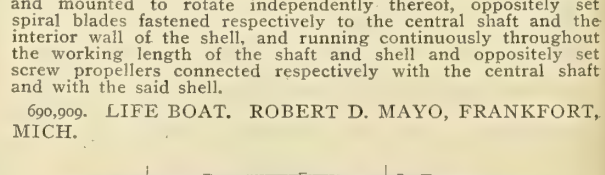
690,821. MARINE PROPULSION. JOHN J. ASTOR, NEW YORK.



CLAIM.—In an apparatus for marine propulsion, the combination with a central rotative shaft, an exterior shell inclosing the shaft and mounted to rotate independently thereof, oppositely disposed spiral blades fastened respectively to the shaft and to the interior wall of the shell, the blade of the shell running across the blade of the shaft, and said blades having their adjacent edges abutting against each other, and oppositely set screw propellers connected respectively with the central shaft and with the said shell.

2. In an apparatus for marine propulsion, the combination of a central rotative shaft, and exterior shell inclosing the shaft and mounted to rotate independently thereof, oppositely set spiral blades fastened respectively to the central shaft and the interior wall of the shell, and running continuously throughout the working length of the shaft and shell and oppositely set screw propellers connected respectively with the central shaft and with the said shell.

690,909. LIFE BOAT. ROBERT D. MAYO, FRANKFORT, MICH.



CLAIM.—In a life boat of the class described, the combination of an outer cylindrical inclosing shell, a transverse bulkhead arranged at or near each end thereof, between which is formed a living compartment, an oscillating carriage in such compartment, and chain mechanism secured to such oscillating carriage and movably mounted on the bulkhead at a point above the axial center thereof to permit independent oscillations of the carriage, substantially as described.